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NOUVELLE SÉRIE

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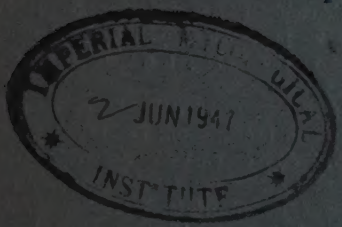

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MATHÉMATIQUES

UN CAS DU THÉORÈME DE JANET-RIQUIER. I

Par N. LUSIN, de l'Académie

1. Enoncé du théorème. On sait que les théories formelles et absolument rigoureuses dues à Riquier et Janet [1] s'étendent aisément à *certains systèmes* d'équations aux dérivées partielles à *autant d'équations que de fonctions inconnues*. S'il y a, par exemple, trois fonctions inconnues u, v, w, on supposera que les trois équations ont respectivement pour premier membre une dérivée de u, une dérivée de v, une dérivée de w:

$$\frac{\partial^{\rho_1+\rho_2+\ldots+\rho_m} u}{\partial x_1^{\rho_1}\partial x_2^{\rho_2}\ldots\partial x_m^{\rho_m}}, \quad \frac{\partial^{\sigma_1+\sigma_2+\ldots+\sigma_m} v}{\partial x_1^{\sigma_1}\partial x_2^{\sigma_2}\ldots\partial x_m^{\sigma_m}}, \quad \frac{\partial^{\tau_1+\tau_2+\ldots+\tau_m} w}{\partial x_1^{\tau_1}\partial x_2^{\tau_2}\ldots\partial x_m^{\tau_m}}.$$

Attachons à chacune des variables x et des inconnues u, v, w $s+1$ nombres entiers qui seront appelés les *cotes* de cette variable ou de cette inconnue, *les cotes premières des variables indépendantes étant toutes égales à* 1. Soient $1, C_{i1}, C_{i2}, \ldots, C_{is}$ les cotes de x_i; $U_0, U_1, \ldots, U_s$ les cotes de u. On attachera à chacune des dérivées de u, $\frac{\partial^{\alpha_1+\alpha_2+\ldots+\alpha_m} u}{\partial x_1^{\alpha_1}\partial x_2^{\alpha_2}\ldots\partial x_m^{\alpha_m}}$, les $s+1$ cotes

$$\Gamma_0 = \alpha_1 + \alpha_2 + \ldots + \alpha_m + U_0$$
$$\Gamma_k = \alpha_1 C_{1k} + \alpha_2 C_{2k} + \ldots + \alpha_m C_{mk} + U_k$$

et l'on opérera d'une manière analogue pour les dérivées de v et de w. De deux dérivées D, D' quelconques de u, v, w (qu'elles proviennent ou non de la même fonction), de cotes respectivement

$$\Gamma_0, \Gamma_1, \ldots, \Gamma_s; \quad \Gamma'_0, \Gamma'_1, \ldots, \Gamma'_s$$

D sera dite *postérieure* ou *antérieure* à D' suivant que la première des différences

$$\Gamma_0 - \Gamma'_0, \quad \Gamma_1 - \Gamma'_1, \ldots, \Gamma_s - \Gamma'_s$$

qui n'est pas nulle, est *positive* ou *négative*. S'il se trouvait que toutes les différences $\Gamma_0 - \Gamma'_0, \Gamma_1 - \Gamma'_1, \ldots, \Gamma_s - \Gamma'_s$ fussent nulles, on rangerait les deux dérivées D, D' dans la même classe.

Les dérivées se trouvent ainsi réparties en classes $C_1, C_2, \ldots, C_\nu, \ldots$ ayant les propriétés suivantes: 1° chaque classe ne contient qu'un nombre fini d'éléments; 2° si $\nu' < \nu$, toute dérivée de $C_{\nu'}$ est antérieure à toute dérivée de C_ν.

Nous supposerons que chacune des équations données ne renferme dans son second membre, outre les variables indépendantes, que des dérivées antérieures à son premier membre.

Donnons-nous comme fonctions initiales arbitraires celles mêmes qui conviendraient au système

$$\frac{\partial^{\rho_1+\rho_2+\ldots+\rho_m} u}{\partial x_1^{\rho_1}\partial x_2^{\rho_2}\ldots\partial x_m^{\rho_m}}=0,\quad \frac{\partial^{\sigma_1+\sigma_2+\ldots+\sigma_m} v}{\partial x_1^{\sigma_1}\partial x_2^{\sigma_2}\ldots\partial x_m^{\sigma_m}}=0,\quad \frac{\partial^{\tau_1+\tau_2+\ldots+\tau_m} w}{\partial x_1^{\tau_1}\partial x_2^{\tau_2}\ldots\partial x_m^{\tau_m}}=0.$$

Le problème que l'on est amené à poser admet sûrement (sous les conditions de régularité habituelles) *une solution* (u, v, w) *holomorphe et une seule*.

Ce théorème comprend comme cas particulier le théorème classique de Cauchy-Kowalevsky (²).

Le théorème est encore vrai si, du second membre de chaque équation, figurent des dérivées non antérieures au premier membre, mais de cote première au plus égale à la cote première de ce premier membre, sous *certaines réserves d'inégalité*.

2. Cas particulier. D'une manière particulière, posons $m=1$ et considérons un système (S) d'équations *différentielles* (et non pas aux dérivées partielles) comprenant autant d'*équations* que de *fonctions inconnues*:

$$\left.\begin{aligned} a_{11}x_1+a_{12}x_2+\ldots+a_{1n}x_n&=b_1\\ a_{21}x_1+a_{22}x_2+\ldots+a_{2n}x_n&=b_2\\ \cdots\cdots\cdots\cdots\cdots\cdots&\\ a_{n1}x_1+a_{n2}x_2+\ldots+a_{nn}x_n&=b_n \end{aligned}\right\}\quad (S)$$

où x_i sont les fonctions inconnues dépendant d'une seule variable t, a_{ij} des polynômes à coefficients constants du deuxième degré en D, $D=\frac{d}{dt}$, et b_i des fonctions données de t.

Adoptons pour la variable t et les fonctions inconnues x_i un système de cotes tel que chacune des classes C_κ qui en résultent ne contienne qu'un élément; c'est ce qui a lieu, par exemple, si nous adoptons le système de cotes suivant*:

t	x_1	x_2	x_3	...	x_n
1	0	0	0	...	0
0	1	2	3	...	n

Le système (S) étant donné, considérons la *dernière* D_1 des dérivées qui y entrent, c'est-à-dire celle qui est *postérieure* à toutes les autres, et résolvons par rapport à elle une des équations du système qui la contiennent; portons l'expression trouvée dans les autres équations; traitons le système obtenu *qui ne contient pas* D_1 comme nous avons traité le système primitif, et ainsi de suite. Nous obtiendrons finalement un système (Σ) d'équations résolues, chacune ne contenant dans son second membre que des dérivées antérieures à son premier membre, les premiers membres étant tous différents. Il est à remarquer que le système déduit (Σ) est *algébriquement* équivalent au système primitif (S) et que les seconds membres de (Σ) sont des expressions *linéaires* par rapport aux dérivées d'ordre 0, 1 et 2 des fonctions inconnues x_i à coefficients constants, sauf les termes indépendants des inconnues formés par les fonctions données b_i. Les premiers membres du système (Σ) et toutes leurs dérivées seront appelées dérivées *principales*; les autres dérivées des x_i seront dites *paramétriques* pour (Σ).

* Autrement dit, les dérivées sont rangées d'après *leur ordre*, *puis* d'après la fonction dont elles proviennent.

Formons les conditions d'intégrabilité complète (C) du système (Σ). Comme toutes ces conditions proviennent de trois identités:

$$\frac{d^2}{dt^2}(x) = \frac{d^2x}{dt^2}, \quad \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2} \text{ et } \frac{d}{dt}(x) = \frac{dx}{dt},$$

nous obtiendrons des relations en nombre fini, ne contenant que la variable indépendante t et les dérivées paramétriques pour (Σ), qui, si le système (Σ) n'est pas complètement intégrable, ne sont pas toutes des identités.

Résolvons ces relations comme nous avons résolu celles du système primitivement donné (S), et joignons les équations obtenues aux équations (Σ). Nous obtenons un système (Σ′) formé encore d'équations résolues, chacune ne contenant dans son second membre que des dérivées antérieures à son premier membre, les premiers membres étant tous différents et *d'ordre* $\leqslant 2$. Les premiers membres D' de (Σ′) comprennent les premiers membres D de (Σ) et *des dérivées qui ne sont dérivées d'aucun des* D, puisque ce sont des dérivées paramétriques pour (Σ). Nous traiterons (Σ′) comme nous avons traité (Σ), et ainsi de suite.

Je dis maintenant que l'opération ne peut se répéter qu'un nombre fini de fois. En effet, l'opération fondamentale, par laquelle on construit les systèmes successifs $(\Sigma^{(\nu)})$, consiste à enrichir l'ensemble des dérivées principales en y joignant des dérivées paramétriques. Or, nous avons vu que ces dernières sont d'ordre $\leqslant 2$ et, par suite, sont en nombre limité. On conclut de là qu'à partir d'un certain rang ν les systèmes successifs $(\Sigma^{(\nu)})$ restent identiques. Par conséquent, il arrivera un moment où l'opération ne pourra se poursuivre faute de conditions (C): le système final obtenu (Ω) *sera complètement intégrable.*

A moins pourtant que l'on ne soit amené à une relation entre plusieurs constantes et la variable t seule, ce qui prouverait *l'impossibilité* du système proposé (S).

Ceci étant, supposons que le système donné (S) est sûrement *possible* et que sa solution générale *ne dépend que de constantes arbitraires en nombre limité*. Nous allons maintenant *caractériser le degré d'arbitraire de la solution* $(x_1, x_2, \ldots, x_n)$ *du système* (S).

Tout d'abord, le système final (Ω) est équivalent à (S) *au sens différentiel* (et non pas au sens algébrique). Etant complètement intégrable, le système (Ω) ne contient dans ses premiers membres que des dérivées des fonctions inconnues entièrement différentes. Et puisque la solution générale de (S) ne peut pas dépendre d'une *fonction arbitraire*, le système final (Ω) contient effectivement dans ses premiers membres des dérivées de *toutes* les fonctions inconnues $x_1, x_2, \ldots, x_n$. On conclut de là que (Ω) est un système à *autant d'équations que de fonctions inconnues*, et comme chacune des équations de (Ω) ne contient dans son second membre que des dérivées antérieures au premier, on voit bien que le système final (Ω) *est mis sous la forme normale de Janet-Riquier.*

Voici la conclusion à laquelle nous arrivons: *tout système* (S), *possible et n'admettant aucune solution dépendant d'une fonction arbitraire, peut être mis sous forme normale de Janet-Riquier* (Ω). *Donc, on peut se donner arbitrairement les valeurs prises, pour une valeur particulière* t_0 *de* t, *par* x_i *et* $\frac{dx_i}{dt}$, *si la seconde dérivée de* x_i *figure effectivement dans* (Ω), *et par* x_i *seule, si* (Ω) *ne contient en réalité que la première dérivée de* x_i; *ces valeurs déterminent entièrement une solution* $(x_1, x_2, \ldots x_n)$ *du système proposé* (S). On voit donc quel est le *degré de généralité* de la solution du système (S):

si (Ω) ne contient pas la seconde dérivée de x_i, l'arbitraire est interdit à $\left(\frac{dx_i}{dt}\right)_{t=t_0}$, et si (Ω) ne contient aucune dérivée de x_i, l'arbitraire est interdit même à $(x_i)_{t=t_0}$. Nous sommes ainsi amenés à prendre extrême précaution pour être certains d'avoir les conditions initiales *compatibles*, c'est-à-dire ceux qui conviennent *effectivement* à une solution. A moins pourtant que l'on ne soit amené au système final (Ω) écrit *sous forme normale de Cauchy*.

Cette voie, jointe au théorème de Cauchy relatif à *une* équation, nous conduit d'ailleurs à une nouvelle manière pour traiter un système (S) d'équations différentielles quelconques.

Remarque. Le premier des problèmes qui se pose au sujet des conditions initiales compatibles est celui de la possibilité des *conditions initiales nulles*: on donne ce nom au système des conditions

$$[x_i(t_0) = 0,\ x_i'(t_0) = 0]$$

l'indice i prenant toutes les valeurs 1, 2, 3, ..., n. On réalise un progrès évident en déterminant un critérium nécessaire et suffisant pour que les conditions initiales nulles soient *compatibles* à l'égard d'un système donné (S) d'équations différentielles. M. V. Koulebakine m'a fait remarquer qu'il serait tout à fait désirable qu'on ait quelques résultats généraux sur cette compatibilité à l'égard des systèmes d'équations différentielles, non linéaires et d'ordre quelconque, satisfaisant à une condition d'invariabilité relativement à x_1. C'est un problème qui mérite d'attirer l'attention des analystes puisqu'il est étroitement lié aux certains problèmes de la mécanique.

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LITTÉRATURE CITÉE

[1] Ch. Riquier, Les systèmes d'équations aux dérivées partielles (Gauthier-Villars, 1910); Ch. Riquier, Mémorial des Sc. Math.; M. Janet, ibid.
[2] M. Janet, Leçons sur les systèmes d'équations aux dérivées partielles (Gauthier-Villars, 1929).

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TECHNICAL PHYSICS

A NEW VACUUM TUBE SCALING CIRCUIT

By V. V. BOVIN

(Communicated by S. I. Wawilow, Member of the Academy, 29. I. 1941)

Methods of high-speed counting of electric impulses have been suggested by Wynn-Williams (1), Lord and Livingston (2), Teichmann (3), Alfven and Ohlin (4) and, finally, by Lifschutz and Lawson (5). These last authors by employing vacuum tubes in a scale-of-two circuit achieved a resolution time of $\tau_* = 6.5 \times 10^{-6}$ sec. [the minimum resolution time attained by a thyratron circuit had been 10^{-4} sec. (1,2,3)]. Among circuits employing vacuum tubes only that of Lifschutz and Lawson possesses a scaling ratio of $K = 2^n$, where n equals the number of units in the circuit. In the circuit of Alfven and Ohlin $K = m^n$, where m is the number of equal portions of the positive charge accumulated on the condenser. However, the counting rate of the Alfven and Ohlin circuit is considerably lower ($\tau_* = 5 \times 10^{-4}$ sec.) than of the circuit of Lifschutz and Lawson.

If use is made of the Trost counter (6) ($\tau_* = 10^{-5} \div 10^{-6}$ sec.), of a proportional counter ($\tau_* = 10^{-6} \div 10^{-7}$ sec.) or of some other device, with a maximum rate of counting many times exceeding that of, say, the Geiger-Müller counter with a cut-off, it will be found that even the nearest to perfection of the known circuits, that of Lifschutz and Lawson, is much too unwieldy, attaining the operating speed of 5×10^6 impulses/second only at the expense of employing more than 100 tubes.

The author has suggested and constructed a circuit, every element of which consists of four vacuum tubes and a kenotron (Fig. 1). This circuit has a considerable advantage over that of Lifschutz and Lawson, so far as the number of tubes employed is concerned, retaining at the same time their scheme's most noteworthy feature—its non-sluggishness.

Positive voltage pulses, having passed the discriminator, are transmitted through the condenser C_1 on to the grid of tube $Л_1$. This grid is direct coupled: 1) to the anode of the diode $Л_2$, and 2) to the cathode of a powerful shielded tube $Л_5$, the grid bias of which is normally sufficient to render it non-conducting even in the absence of positive pulses. The grid of $Л_1$ is grounded only through an equivalent leakage resistance R_1 including plate resistances. An input pulse, the magnitude of which $U = 40 \div 150$ volts, even if its duration $\tau = 10^{-7}$ sec. (e times its waning time), will, in the case of a diode 5Z4-C ($Л_2$) bring on to the grid of tube $Л_1$ a negative charge, characterized by a potential change of the order $0.1 \div 1$ volt. This drop satisfies the formula:

$$\Delta U_{11} = \frac{\bar{I}_{\mathfrak{a}} \tau}{C_1} e^{-\frac{t}{C_1 R_1}} \qquad (1)$$

where $\overline{I}_2$ is the current passing through $\mathit{Л}_2$, arbitrarily averaged for the time interval $\tau \ll C_1R_1$. The grid potential change ΔU_{11} causes a proportional change ΔU_{a11} of the value of the potential drop in the plate resistance R_{a1}. The duration of these potential changes is of the order of τ; after this period ΔU_{a11} slowly diminishes in accordance with the same exponential law as that which governs ΔU_{11}.

Any subsequent pulse No. $(k+1)$ acts upon the grid of tube $\mathit{Л}_1$ in such a manner, as if its magnitude were not U, but $(U-U_{1k})$, where U_{1k} is the grid potential of $\mathit{Л}_1$ after k pulses $(k=0, 1, 2, \ldots)$. If conditions $U \gg U_{1k}$ and $R_1C_1 \gg t$ are observed, the readings of the meter recording the value of U_{a1k} change by steps, always proportional to k, in so far as

$$U_{1k}=U_{10}+\sum_{k=1}^{k}\Delta U_{1k}=U_{10}+k\Delta U_{11} \quad (U \gg U_{1k},\ R_1C_1 \gg t), \tag{2}$$

where U_{10} is the grid bias of tube $\mathit{Л}_1$. However, even when $U=2U_{1k}$ the value of the $(k+1)$ step becomes but half that of the first.

In this manner the accumulation of negative charge on the grid of $\mathit{Л}_1$ goes on until $k \leqslant m-1$, and here may easily be made to practically equal, say, 50.

A pulse No. m during a time interval of the order of τ must: 1) cause the reading of the next unit or eventual mechanical recorder to go up by one; 2) reduce the grid of $\mathit{Л}_1$ to its initial condition. These operations are conducted with the aid of tubes $\mathit{Л}_3$, $\mathit{Л}_4$ and $\mathit{Л}_5$, of which $\mathit{Л}_3$ and $\mathit{Л}_5$ are all the time non-conducting, while $\mathit{Л}_4$ is conducting. Every m pulse applied to the input brings about a complete phase-shift; tubes $\mathit{Л}_3$ and $\mathit{Л}_5$ become conducting, while $\mathit{Л}_4$ is rendered non-conducting. This is achieved thus: the main potential applied to $\mathit{Л}_3$ and corresponding to the resistance R_{a1} (fixed at $\pm 1\%$) is corrected by the potentiometer P_1 which diminishes the absolute value of the potential, so that the $(m-1)$ step in the potential change must appear to the left of the bottom bend of the grid plate characteristic curve $[I_a=f(U_g)]$ of $\mathit{Л}_3$, while the m-th step appears to the right. The last potential leap ΔU_{a1m} must not be less than 2 – 3 volts. The change of potential experienced by the anode of $\mathit{Л}_4$ is transmitted either to the mechanical recorder (e. g. by means of a thyratron) or to the next scaling unit.

For the functioning of the circuit it is essentially necessary that the time τ_0 which is required by the tube $\mathit{Л}_5$ for each working beat, and the average current $\overline{I}_5$ during this time interval, be just sufficient for the charge $C_1m\Delta U_{11}=m\overline{I}_2\tau$, accumulated by the grid of tube $\mathit{Л}_1$, to be taken off, i. e.

$$\overline{I}_5\tau_0=m\overline{I}_2\tau \quad (U \gg U_{1m} \text{ and } C_1R_1 \gg t), \tag{3}$$

But this alone is insufficient. The requirement that the circuit be practically inertialess is equivalent to the conditions of the type

$$\tau_0=a\tau \quad \left(\frac{1}{2}<a<m\right). \tag{4}$$

Here small values of a, e. g. $a=1/2$ or $a=1$, keep the percentage of random pulses not recorded by the circuit almost at such a level as that, which corresponds to the resolution time of the counter, amplifier and discriminator, i. e. to the time τ. The value of $a=m$ increases this percentage about threefold, unless it is too great $(1-2\%)$. This is easily

understood, if one takes into consideration the fact that the time during which the m pulse is held up (this time is approximately twice as great as τ_0 during which the charge is taken off) statistically acts so, as if the average duration τ of each of the m input pulses was increased by $2\tau_0/m$. The case of $\tau_0 \ll \frac{1}{2}\tau$ involves too rigid a requirement, since even at a maximum rate of input pulses, corresponding to their occurrence at regular intervals separated by a period of 2τ, it is sufficient for the recording of all the pulses that $2\tau_0 = \tau$. The time τ_0 is regulated by the proper choice of condensers linked parallel with the anode loads of tubes $\mathcal{J}_3$ and $\mathcal{J}_4$.

The values of U_{a1k} are measured by some non-sluggish direct current device. The cathode ray oscillograph is particularly suited for this pur-

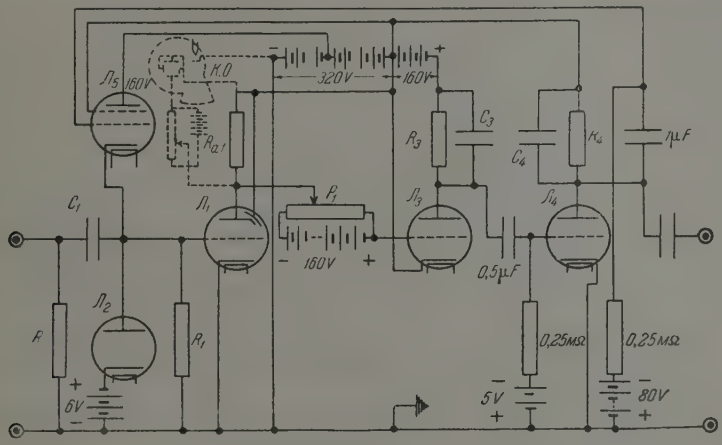

Fig. 1.

pose (see dotted line in Fig. 1). If $m \cdot 20$, the switching of special devices into the circuit for measuring U_{a1k} may be avoided altogether, through the use of an electron ray tube $6E5$ in place of the tube $\mathcal{J}_1$ (this is shown in Fig. 1). When $m > 6$, it was found possible to take readings with the aid of a scale in the eyepiece fitting of a microscope ($\times 10$), focussed upon the screen of $6E5$.

The fundamental criterion for choosing the circuit constants and the tubes $\mathcal{J}_2$ and $\mathcal{J}_5$ is easily derived from (3) and (4):

$$\bar{I}_5 : \bar{I}_2 = m : a \quad \left(\frac{1}{2} \leqslant a \leqslant m\right) \tag{5}$$

or, taking (1) into consideration:

$$\bar{I}_5 = \frac{m}{a} \frac{C_1 \Delta U_{11}}{\tau}. \tag{6}$$

From (6) follows the desirability of selecting the capacitance C_1 as small as possible. This is to some extent inconsistent with the requirement that $R_1 C_1 \geqslant t$, which serves to prevent systematic counting losses, due to the charge leaking off during operation or while the readings are being taken. A simple calculation makes clear that at the lowest possible

counting rate, corresponding to a combination of one scaling unit and mechanical counter, and equal to m pulses per second (allowing for a counting losses of 1%), this last demand becomes still stricter:'

$$R_1 C_1 \gg m\left(\frac{1}{2}+\Delta t\right) \tag{7}$$

where Δt is the time required to take the readings and is reckoned from the moment the charge is stored up after k pulses. However, even this requirement may be fulfilled in practice by means of thoroughly developed system of precautions against excessive leakage in insulation and vagabond currents in the tube. With the increase in the rate of counting, requirement (7) gradually becomes less strict, and when the rate of $(2\tau)^{-1}$ pulses per second is reached, it passes into the inequality

$$R_1 C_1 \gg m(m\tau+\Delta t). \tag{8}$$

Condition (7) and especially (8) may easily and reliably be fulfilled with complete accuracy at photographic recording of the readings (exposure $\Delta t \approx 10^{-2}$ sec.). However, an experimental verification easily convinces us that an ideal balance between $Q_5 = \bar{I}_5 \tau_0$ and $Q_2 = m\bar{I}_2\tau$ is hardly essential. Thus, with no special jousting of the circuit, the author was able to test two hundred series of pulsations, each of which was always terminated on the twentieth pulse exactly ($m = 20$), in spite of the fact that Q_5 was quite intentionally varied (within the limits of $\pm 2\%$). This property of the circuit can be accounted for theoretically.

At a given value of K the number of tubes in our circuit, which operates with n units and with a scaling ratio of m^n, diminishes in comparison to the circuit of Lifschutz and Lawson $2.66 \lg_{10} m$ times. The achieved average resolution time of the circuit, at maximum rates of 2×10^5 sec^{-1}, limited by the time τ_0, is equal to 1.4×10^{-6} sec., and at low rates — to 2×10^{-7} sec.

These results do not, however, exhaust the circuit's possibilities. (6) and (8) place the maximum rate at

$$1/2\tau = \bar{I}_5/4mC_1\Delta U_{11} \ll R_1\bar{I}_5/4m^2\Delta t\Delta U_{11}. \tag{9}$$

Here only the value of $\Delta t \approx 0.5$ sec. has been used, therefore the transition to photographic recording of the readings (at $\Delta t \rightarrow 10^{-2}$ sec.) will further increase the counting rate at least tenfold.

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CHEMISTRY

ON THE NATURE OF STABLE BOUND WATER IN THE PRECIPITATE OF BARIUM SULPHATE

By A. P. RATNER and V. I. KUZNETZOVA

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It has been found out long since that the precipitate of barium sulphate contained water that could not be eliminated by simple drying at 100°C. The amount of this water varied as to the method of preparation of the precipitate and, according to the data of Balarew (1), could reach 3.5%. De-Brouckère (2) has found that when the precipitate of barium sulphate was heated, the water it contained was eliminated within a short temperature range, between 250 and 300°; from this fact she drew the conclusion that water was adsorbed on the surface of the precipitate and was stably held by adsorption forces. This assumption was supported by the fact that, according to the data of De-Brouckère, the adsorbed water was displaced by potassium chloride, and that after treatment with a 3 *N* solution of potassium chloride practically all the surface of barium sulphate was occupied by the latter, the amount of adsorbed water having decreased almost to zero. However, Kolthoff (3) was unable to reproduce the results of De-Brouckère with a $BaSO_4$ suspension prepared in his laboratory, nor with a sample sent by De-Brouckère of a suspension used by her. De-Brouckère (4) investigated a sample of the suspension obtained in Kolthoff's laboratory and found that it contained a considerable amount of water that could be eliminated through heating within a wide temperature range (150—300° C), the water being of a non-adsorption nature. When the dried precipitate was again treated with water, it retained a much smaller amount of water that could be eliminated within a short temperature range and the quantity of which corresponded to that of the water retained by the preparations of De-Brouckère, if the magnitude of the specific surface of both precipitates was taken into account.

Taking into consideration the interest that such a simple method would have for the determination of an adsorbed solvent, we decided to investigate closer the water that could not be eliminated at 100° C from precipitates of barium sulphate studied in this laboratory and having different surfaces.

In this investigation 3 suspensions of $BaSO_4$ were used. No. 1 was prepared some years ago from 1 *N* solutions of barium chloride and sulphuric acid. To a solution of barium chloride, under mechanical stirring and at room temperature, sulphuric acid was added. The $BaSO_4$ precipitated was repeatedly washed with water ($\varkappa = 1.8 \times 10^{-6}$) to constant electroconductivity. No. 2 was prepared at 100° C from 0.1 *N* solutions of barium chloride and sulphuric acid. Suspension No. 2, as well as the former one, was washed to

a negative reaction to Cl' and to constant electroconductivity of its saturated solution. No. 3 was prepared at room temperature from 1 N solutions of magnesium sulphate and barium nitrate and washed to constant electroconductivity and constant ζ-potential.

First of all the temperature range was determined, within which the remaining water was eliminated from the precipitate of barium sulphate after a preliminary drying of the precipitate to constant weight at 100° C. Barium sulphate was placed into small weighing bottles and heated at different temperatures to constant weight. In the majority of runs the determinations were carried out using a microbalance, and only in those cases when large amounts of the precipitate were taken—usual analytical balance was employed.

All the starting materials were recrystallized twice.

Table 1

Loss in Weight of Barium Sulphate through Heating

t °C	Weight of eliminated water per 1 g				Notes
	I	II	III	IV	
150	0	0	0	0	I, II, III, IV— different samples of the same suspension. Temperature of the oven was measured by means of a thermocouple with a 5° accuracy.
230	3.4	3.3	3.5	3.3	
300	7.5	7.4	7.2	7.9	
330	8.8	9.0	—	—	
350	11.8	11.8	11.8	11.6	
400	12.7	13.0	12.8	12.6	
450	12.7	12.8	12.6	12.8	

As may be seen from Table 1, water is eliminated gradually within the range of 150—400°. The major part of the water was eliminated within the range 200—350°. If the water eliminated from the precipitate was adsorbed on its surface, a repeated treatment with water of a precipitate already heated to 400° would lead to similar conditions of its elimination, as during the first heating period. But if this water was included in crystals and got within during their growth and recrystallization, in the case of a second drying the water should be eliminated from $BaSO_4$ crystals by heating the latter to 100° C. Besides, if this water was inside the crystals, the surface of the precipitate after heating to 400° C should increase, owing to the cracking of the crystals during the elimination of water. Experiments carried out in this direction (Table 2) have shown that after a second treatment of samples heated to 400° C practically all the water was eliminated at 100° C.

Table 2

	Suspension No. 1		Suspension No. 2		Suspension No. 3	
Weight of precipitate after heating to 400°C	1.5721	1.5565	1.13638	0.98928	6.1720	3.6741
Weight of precipitate after treatment with water and heating to 100°C	1.5720	1.5566	1.13638	0.98924	6.1720	3.6742

The surface of the precipitate of barium sulphate was determined by the adsorption of radium on it ([5]). The magnitude of the specific surface of $BaSO_4$ increased after heating to 400° C; before heating it was 3.8×10^{-3} g $BaSO_4$ per 1 g of the precipitate, after heating to 400—8.6×10^{-3}. When the precipitates were heated to 500° C, sintering of the particles was observed, but without further loss in weight. As it was to be expected, the surface at a temperature of 500° decreased from 4.5×10^{-3} g $BaSO_4$ per 1 g of the precipitate prior to heating to 1.14×10^{-3} g after heating to 500°.

The experiments of De-Brouckère on the displacement of «adsorbed» water by a 3 *N* potassium chloride solution have been repeated using two suspensions. The results obtained are given in Table 3.

Table 3

	Suspension	Suspension
Amount of water, eliminated from 1 g of the suspension at 400°	12.9 mg±0.2	3.5 mg±0.1
Amount of water, eliminated from 1 g of the suspension at 400° after treatment with 3*N* KCl	13.4 mg±0.1	3.4 mg±0.1

Besides, experiments (determination of water) were carried out using suspensions of different surfaces. If the water eliminated from barium sulphate above 100° C would have been adsorption water, the amount of water eliminated from the surface should be proportional to the magnitude of the surface of the precipitate. Data recorded in Table 4 show the absence of such a proportionality.

Table 4

	Susp. No. 1	Susp. No. 2	Susp. No. 3	Notes
Amount of H_2O in mg eliminated from 1 g at 400° . . .	12.8	5.4	11.7	Accuracy of determination 2%
Magnitude of specific surface in m^2 .	2.0	0.23	2.4	Accuracy of determination 5—6%

On the basis of the experiments described above, it can be affirmed that water eliminated from the precipitate of barium sulphate above 100° is no absorption water, but water included in crystals, and that the method suggested by De-Brouckère for the determination of the amount of solvent adsorbed on the precipitate of barium sulphate is erroneous.

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GEOCHEMISTRY

PROSPECTING EVIDENCE FOR INDIUM

By N. M. PROKOPENKO

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Indium is widely distributed in nature but in very minute quantities. High concentrations of indium are very rare; the concentration of the element in minerals does as a rule not exceed thausendths of a per cent.

That the concentration of indium is not persistent in different genetic types of deposits, sometimes in one and the same deposit and even mineral, can readily be demonstrated by an analysis of distribution of indium over some territory. When on a certain territory there appears some metallogenic cycle enriched with indium, an accompanying enrichment of ore-deposits of the given territory with indium takes place (rôle of the regional factor). Although the conception of geochemical province as applied to scattered minerals is somewhat arbitrary, the author of the present paper believes the distinguishing of geochemical provinces, enriched with indium or impoverished in it, to be quite rational. The accumulation of analytical data will in future make possible an attempt to calculate some mean figures, pertaining to the distribution of a given element in ore-deposits of a certain territory, to be made («clark» of an element in ore-deposits). Then a comparison of generalized numerical values thus obtained for different territories will give a quantitative expression for the extent of enrichment of the given territory with this or another element.

Northern Kirghizia and Eastern Transbaikal may be considered at the present state of knowledge as enriched with indium, while Altai and Salair are impoverished in it. Other regions, the Urals e. g., occupy in this respect an intermediate position. In future detailed investigations will undoubtedly aid in discovering new regions enriched with indium; at the present time the analytical data for these regions are too scanty for any definite conclusions to be made.

Vertical zonality, comparatively seldom observed in polymetallic deposits, is expressed by a variation of quantitative ratios of minerals with depth (decrease of the amount of galenite, increase of sphalerite, substitution of sphalerite by pyrite and chalcopyrite, etc.) and also by an alteration of typomorphic peculiarities of minerals (sphalerite in deeper horizons of some deposits acquires a darker colour, being enriched with iron). Thus e. g., in the Sadon deposit opened by mining to the depth of 800 m sphalerites display a tendency (though not distinctly pronounced) to get darker in colour in deeper horizons of the deposit. An analogous phenomenon, but to a smaller extent, is observed in the Ak-tus deposit (Northern Kirghizia), where in higher horizons we find sphalerites containing 6.5% of iron (drift No. 1),

while in deeper seated horizons are encountered black sphalerites of the marmatite type with an increased iron content (8.4%).

The distribution of indium in sphalerites depends in some way upon the concentration of iron in them. In the Sadon deposit indium more frequently occurs in darker ferruginous sphalerites. The following data may be of interest in this connexion: 30 specimens of sphalerites, of which 15 were taken from the upper and 15 from the lower horizons of the deposit, were examined spectroscopically; indium was detected only in one specimen from the higher horizons, whereas 11 specimens from the lower horizons were found to contain indium. Thus, indium is more frequently contained in sphalerites with greater iron content from the lower horizons of the deposit. In Ak-tus higher concentrations of indium are usually found in the black sphalerite from the drift No. 2, i. e. in the lower horizons of the deposit.

In this connexion it should be pointed out that the frequency of occurrence of indium is increased only in those deposits, in which typomorphic peculiarities of sphalerites show a change toward an increased iron content, although this is perhaps just a tendency and not a well expressed regularity. Some deposits, the Sadon e. g., display in different horizons local increase of iron content in sphalerites, connected with the conditions of their deposition.

In spite of the fact that the indium content in sphalerites is not persistent, the phenomenon of zonality in the distribution of indium, observed sometimes in the case of zinc-lead deposits, deserves to be examined closer, since it might offer a practical clue to the evaluation of the occurrence of indium on different horizons of ore-deposits.

Prospecting for indium should be conducted preferably in polymetallic deposits of the hypo-hypo-meso- and mesothermal types, in which indium is concentrated chiefly in sphalerites, and to a smaller extent in other sulphides. Tin deposits, particularly those containing sulphostannates of lead and antimony (kilindrite, frankeite, tillite) are also of interest. Black ferruginous sphalerites are especially rich in indium; such sphalerites are usually formed in relatively early phases of the process of mineral formation. Dark sphalerites and black marmatites are more frequently encountered in hypo- and hypo-mesothermal sulphide deposits.

Spectroscopic analysis on a large scale should be adopted as a method of prospecting for indium, sulphides being the chief object of investigations. In this manner a rather quick distinguishing of ore-deposits and, later on, of separate regions, characterized by the presence of indium, may be achieved.

Enrichment of sulphide deposits of the given metallogenic cycle (and, consequently of a certain territory) with indium and even a sufficiently wide distribution of indium within the boundaries of the given region (be it even in low concentrations) may be taken as a favourable evidence for prospecting. Genetic type of the deposit and phase of the ore-process also play a substantial rôle. Mineral associations may serve as prospecting evidences for indium, the presence of indium in complex sulphide-cassiterite depostis (Ak-tus, Kurgan, Kyzyl-espe, Sinancha, etc.) being of special importance. Geochemical association with an ore-complex in which, besides zinc and lead sulphides, a certain rôle is played by tin, is also typical of indium. This type of deposits is favourable for increased concentrations of indium. Besides polymetallic deposits, indium should be looked for in hydrothermal ore-deposits, as well as contact deposits enriched with sulphides and tin, although, as far as indium is concerned, practical value of the last type of deposits is not yet obvious.

Prospecting evidences for indium are as follows:

1) Association of this element with acid and moderately acid granite and granodiorite intrusions of hypabyssal nature.

2) Enrichment of the given magmatic source or its separate derivates with indium; this enrichment is expressed in space by a relative enrichment of the given ore province or its separate parts with indium.

3) Genetic type of deposits (hypo-hypo-meso- and mesothermal polymetallic deposits and also meso- or meso-epithermal tin deposits of the Bolivian type are particularly favourable for indium).

4) Geochemical association of indium with such ore complex in which, besides sulphides, a certain rôle is also played by tin (sulphide-cassiterite and, in general, sulphide-tin type of the deposit).

5) Association with definite mineral species (dark-coloured sphalerites, sulphostannates of lead and antimony—kilindrite and frankeite; indium, though to a smaller extent, is distributed in cassiterites and wolframites).

6) Possible, but not obligatory association of indium with deeper horizons of some polymetallic deposits, in which vertical zonality in the distribution of darker sphalerites in depth is observed.

Main regions of the USSR in which further prospecting for indium stuff is desirable are as follows: Kirghizia, Tadjikistan, Caucasus, Eastern Transbaikal, Kazakhstan, Far East and also new ore-bearing regions Yakutia, Kolyma and the Chukotsk peninsula.

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GEOCHEMISTRY

OCCURRENCE OF INDIUM IN VARIOUS METALLOGENIC CYCLES OF THE USSR

By N. M. PROKOPENKO

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Indium occurs on the territory of the USSR in ore-deposits genetically related to ancient as well as young metallogenic cycles (Upper Cambrian, Caledonian, Variscian, Cimmerian, Lower Cretaceous and Alpian).

So far the occurrence of indium in connexion with the most ancient cycles has been inadequately elucidated. According to data presented by A. N. Churakov (3), the indium containing auriferous deposits Communar and Sarala in the Kuznetzk Alatau are related to the Upper Cambrian cycle. The pyrite deposit Achik-tash (Northern Kirghizia), in which but traces of indium are present, is arbitrarily referred to the Caledonian cycle.

The Variscian metallogenic cycle was of great importance for indium. This cycle manifests itself in a number of main ore-bearing regions of the USSR: in Kirghizia, Uzbekistan, Tadjikistan, on the island Vaigach, in the Urals, Kazakhstan, Altai and conditionally in Salair and the Nagolny ridge, but for the two last-named regions the Variscian age of lead-zinc deposits has not been accurately proved.

Polymetallic deposits formed during the Variscian cycle are genetically associated with granodiorites and granites. In several ore-bearing regions the supposed metalliferous intrusions were of hypabyssal character (Karamazar, Kirghizia, Altai, Kazakhstan).

Indium, in general, is an element typical of the Variscian cycle. Increased and even rather sufficiently high concentrations of indium are met with in a number of ore-deposits of the Variscian cycle, both in the USSR (Kirghizia, Tadjikistan, Kazakhstan) and abroad (Germany). Such concentrations are associated with this metallogenic cycle in lead-zinc deposits Ak-tus, Buurdu, Kyzyl-espe, Darbaza, Kan-say, Kalata, etc. in the USSR, and in the deposits of Freuburg and Klausthal in Germany.

The frequency of occurrence of increased concentrations of indium within the limits of the Variscian cycle is different in various regions of the USSR. This cycle, on the whole, was enriched with indium, but the distribution of indium throughout various areas and in ore-deposits of different genetic types is non-uniform. Thus, Kirghizia e. g. is enriched with indium, while Altai and Salair are noticeably impoverished in it. Other regions, the Urals e. g., occupy in this respect an intermediate position.

Indium occurs in deposits of various genetic types, among which the greatest practical importance belongs to the polymetallic deposits: hypothermal

(Ak-tus), hypomesothermal (Buurdu, Kan-say, Kalatau) and mesothermal (Kyzyl-espe, etc.).

The Cimmerian or, most probably, Upper Jurassic metallogenic cycle widely manifests itself in Eastern Transbaikal, an enormous polymetallic ore-bearing region. Mineralization is associated with hypabyssal and abyssal facies of rocks of the granite and granodiorite composition. Polymetallic deposits are of a telescopic character. Noteworthy is the wide range of occurrence of indium in the Upper Jurassic cycle of Transbaikal, where it is found in polymetallic, gold-polymetallic, tungsten, tin and sulphide-cassiterite deposits.

The Cimmerian cycle of Transbaikal is enriched with indium. In a number of deposits indium occurs at relatively high and increased concentrations (Kadainsk, Klichky, Darasun, Khapcheranga, Tarbaldjey, etc.). A noticeably increased indium content is typical of the dark-brown sphalerite of the Kadain mine. Marmatites from Darasun are characterized by markedly and steadily increased indium concentrations. Indium is characteristic of zinc ores of the complex tin-polymetallic deposits of Khapcheranga. The Tarbaldjey tin deposit offers an interesting example of a high temperature deposit with indium present in a number of minerals (sphalerite, cassiterite, wolframite). Frequent occurrence of indium and, sometimes, even its persistent concentrations in cassiterites of various deposits is typical of Transbaikal.

The occurrence of indium in the Cimmerian cycle of Eastern Transbaikal is of industrial importance, and several ore-deposits contain the stuff fit for extraction of indium. It may be supposed that Eastern Transbaikal will become in future one of the important regions supplying the industry with indium stuff.

The Lower Cretaceous metallogenic cycle covered a huge territory of the North-East of the Siberia (Yakutia)—from the Eastern Verkhoyan nearly to the Chukotka peninsula. The Verkhoyansk-Kolyma ore belt seems to be the most important area, as it follows from the data available. According to the data of S. S. Smirnov (1) and S. S. Smirnov and V. A. Tsaregradsky (2), the deposits are genetically associated with granites and granodiorites, and in a number of regions mineralization is confined to hypabyssal intrusion. Sulphide-cassiterite, lead and silver deposits as well as a wide distribution of tin in sulphide ores, are most characteristic of this cycle.

Although the data on the occurrence of indium in the Lower Cretaceous cycle of the North-East of the Siberia are too scanty, the presence of indium can already be ascertained in several deposits (Imtandja, Lower Endybal, Kulu). An increased indium content has been observed in black sphalerite from the sulphide-cassiterite deposit Imtandja, in mangan-siderite from the Lower Endybal silver-lead deposit and also in dark-grey sphalerite from the basin of the river Kulu. Small quantities of indium are found in cassiterite from the deposit Echy. The wide development of sulphide-cassiterite deposits and the character of metalliferous intrusions give sufficient ground for supposing indium to be widely distributed in the ore-bearing deposits of the Lower Cretaceous cycle of Yakutia.

The Alpian metallogenic cycle is developed in the Caucasus, Kopet-dag, the Far East and the Chukotka peninsula. Deposits of the Chukotka peninsula are usually referred to the Cimmerian-Alpian cycle, polymetallic and copper deposits of the Transcaucasia—to Post Pliocene and, finally, deposits of the Far East—to Upper Tertiary. It should be pointed out, however, that in a number of instances some deposits are referred to the Alpian cycle rather arbitrarily.

Indium is encountered in sphalerites from polymetallic deposits of the Caucasus (Zangezur, the Shaumian mine, Kattar-kavart, Kedabek, Idjevan,

Achtala), Far East (Sinancha, Stalin deposit, Tetukhe, Vanchin) and of the Chukotka peninsula (Piikun, Serdze-kamen, etc.).

The Alpian cycle (in a wide sense) is of great importance as far as possible sources of indium stuff on the territory of the USSR are concerned. Even now some deposits supply the zinc stuff enriched with indium (Kafan zinc concentrate, zinc and zinc-lead concentrates from Sinancha).

In conclusion it should be noted that our present knowledge as to the occurrence of indium in the most ancient metallogenic cycles is very limited, this being due to the difficulty in referring various ancient deposits to a definite cycle with some degree of certainty; marked erosion which has demolished numerous sulphide hydrothermal deposits is also responsible for this situation.

Among the younger cycles indium is also very typical of the Variscian metallogenic cycle. The existing data lead one to the belief that on the territory of the USSR indium more frequently occurs in ore-deposits associated with this cycle. It is to be mentioned, however, that young metallogenic cycles are but little investigated as far as rare and scattered elements are concerned (Yakutia, the Far East, the Chukotka peninsula). We do not doubt that the younger cycles (Mesozoic, Alpian) will be found upon closer examination to be enriched with indium within the boundaries of separate areas. We may already assert that indium is an element typical of the Cimmerian cycle of Eastern Transbaikal. Several ore-deposits of the Alpian age in the Caucasus, Far East and Chukotka peninsula are also characterized by an increased concentration of indium.

L. de Launay and G. Urbain ([4]) were of the opinion that more ancient sphalerites were enriched with indium as compared to younger sphalerites, and explained this phenomenon by a greater depth of crystallization of more ancient sphalerites. Sphalerites of different age, however, may contain indium in increased and even high concentrations, this depending upon a number of causes and primarily upon the geochemical character of the given magmatic source (degree of its enrichment with indium) and upon the mode of formation of the sphalerites themselves. The formation of sphalerites is indeed favoured by conditions prevailing at a greater depth, but such conditions may exist during different metallogenic cycles. Ore-deposits associated not only with the most ancient, but also with young metallogenic cycles should be closely studied with respect to indium.

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GEOCHEMISTRY

DISTRIBUTION OF INDIUM IN URAL ORE-DEPOSITS

By S. A. BOROVICK and N. M. PROKOPENKO

(Communicated by A. E. Fersman, Member of the Academy, 23. I. 1941)

During the Paleozoic era the Urals underwent two intrusive magmatic cycles; most of the intrusions in the Urals belong to the Upper Paleozoic era. According to the data of E. E. Zakharov and S. A. Yushko (2), the first Paleozoic cycle was associated with basic magma and its ultrabasic and acid differentiates. During the second cycle granites were intruded.

The copper-pyrite deposits of the Urals are the most interesting as regards indium. E. E. Zakharov classifies these deposits as follows: 1) hypo-mesothermal (Kalata, Zyuzely), 2) mesothermal (New-Levin, Degtyar, Voroshilov, etc.) and 3) copper-zinc deposits (Karpushikha, Levikha, etc.).

Ural zinc blends are distinghished by their pale colouring, the highly coloured black varieties being very rare. The sphalerite of the Ural pyrite and copper-zinc deposits do by no means always contain indium, which can be discovered by spectral analysis (indium was not found in about 50% of all the sphalerites analyzed). In the Ural zinc blends prevail low indium concentrations.

High indium concentration was observed in solitary samples of sphalerite from the Kalata and Zyuzelsky mines, and also in sphalerite from mt. Blagodat. The Zyuzelsky and Kalata deposits are of the hypo-mesothermal type, i. e. were formed at relatively higher temperatures than most of the Ural pyrite deposits.

F. I. Abramov and A. K. Rusanov (1) observed high concentrations of germanium, indium and gallium in Karpushikha cleiophans, as well as high concentrations of indium in Kalata sphalerites, and fairly high concentrations of indium in sphalerites from mt. Blagodat. We found small quantities of indium in two of the samples of Karpushikha cleiophans; in three others we found none at all (this shows that indium concentrations are rather variable, which is characteristic of this element).

High indium concentrations are found also in the zinc concentrates of the Krasnoural mine and the Kirovograd concentrating mills, which handle ore from the Levikha, Karpushikha, Kalata and Belorechka deposits.

F. I. Abramov and A. K. Rusanov (1) observed that the elements, including indium, are scarce in contact deposits, viz. the Frolov and Turyin deposits (this is in agreement with our data on the Frolov deposit).

In the course of our work we discovered indium in the sphalerites of the following Ural deposits: Karpushikha, Kalata, Zyuzely, Frolov, Berezov, Blagodatny, Karabash, Kuznechikha, Levikha, Krasnoural, the Schmidt

mine, Andreev, Sibai, Bakr-uzyak, Yulaly and Gumerovo. The concentrations of indium are usually low, except in the deposits mentioned above. In Zakharov's work indium was discovered qualitatively by means of a spectroscope in average samples from the Karpushikha, 3rd International, Blagodatny, Rudyano, Ivanovo, Levikha 3, 4 and 9, Aramily, Frolov and Bogoslov deposits.

Indium occurs in low concentrations in wolframites of the Aidyrlya and Fuadov deposits, in rhodochrosite from the Sapal mine, in copper pyrite from Karpushikha and in chalcopyrite from Karabash. The Nigrizoloto spectroscopic laboratory reports the discovery of indium in native gold from the Kumak and Zolotaja Gora deposits (Karabash).

Interesting results were obtained by V. S. Syrokomsky and A. K. Sharova ([4]) at the Ural branch of the Academy of Sciences, in course of a chemical study of the tailings of the Ural non-ferrous metal industry. Low concentrations of indium were discovered in the reverberatory furnace dust of the Krasnoural works, in the converter dust of the Kirovograd works (traces), in the converter dust of the Karabash works, in the copper cake and Cottrell dust of the Cheliabinsk zink works.

According to the data received in connexion with our work, the indium concentrations in the middlings and tailings of the Cheliabinsk zinc works are generally low. Indium has been discovered in the return, copper and tailing cakes. The indium concentration in the return cake is somewhat higher (not only Ural, but also Altai zinc concentrates were handled simultaneously by the plant).

In summarizing this account on the distribution of indium in the Urals it must be emphasized, that indium occurs quite often in the pyrite and copper-zinc deposits of the Urals, and the ores of some of these deposits might apparently serve as raw material for the industrial extraction of indium. The Ural copper-zinc deposits are especially interesting in this connexion, since considerable deposits of zinc ores are centered there.

The high concentration of indium in the zinc-concentrates of the Krasnoural mine and the Kirovograd concentrating mills is also quite conspicuous. It is quite possible that the zinc ores of some of the Ural deposits might serve as raw material for indium extraction, but the distribution of indium in these deposits (Karpushikha, Karabash, Levikha, Zyuzely, etc.) requires a more detailed study. The indium concentrations in the sulphide ores of the Bakruzyak and Yulaly deposits, Baimak region, South Urals, is quite consistently low. In future works a more detailed study of the distribution of indium in the Urals must be made in order to put it to practical use.

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GEOCHEMISTRY

ON THE CONTENT OF GERMANIUM AND OTHER RARE ELEMENTS IN TOPAZES AND BERYLS OF THE USSR

By S. A. BOROVICK

(Communicated by A. E. Fersman, Member of the Academy, 15. I. 1941)

Spectral analysis gives the best results in studying the composition and distribution of rare elements in mineral raw materials. This paper presents the results of determining Ge, Ga, Sc in a large number of samples of topaz from various deposits in the USSR and in a few beryls taken from one of the deposits (Emerald mines). A number of foreign samples were also analyzed for the sake of comparison. The data of these analyses are given in the table below. Since the main components of topazes are aluminium and silicon (Al_2O_3—57%; SiO_2—33%), we found it possible to use one of these elements in comparing the brightness of the germanium lines. The brightness of Ge lines ($\lambda = 3039$ Å) and Al lines ($\lambda = 3060$ Å) were measured. The error in determining the germanium concentration from the calibration curve obtained in this manner is 10%. The spectrograms were obtained by burning the sample in the flame of an arc; for the first part of the exposition (150 sec.) the carbon with the sample was the negative pole; for the rest of the exposition (200 sec.) the direction of the current was reversed; current—8 amp., tension—110 volts.

Samples 3, 4, 5 were chipped off from the same crystal; so were samples 7 and 8, 20 and 21, 25 and 26; the closeness of the data obtained on the Ge content shows that this method of determining Ge is quite accurate. On the other hand, samples 13 and 14, 20 and 21 which showed considerably varying Ge content, were taken from different pieces of topaz, although from the same deposit.

The topazes were tested for gallium as well as germanium; samples 1, 2, 3, 8, 10, 12, 19, 20, 21 have no gallium lines, sample 29 has insignificant traces (app. 10^{-4}%), and 6, 7, 13, 14, 15, 17, 18, 22, 23, 26 contain app. 10^{-3}% Ga. The rest contain about 0.005%; thus, it must be concluded that gallium distribution in topazes is entirely different to that of germanium. It is curious that quite considerable concentrations of chromium were observed precisely in those topazes which gave no germanium lines (samples 1, 2, 10, 27); this may possibly account for the colour of these topazes. Vanadium lines were observed in the same topazes. Of interest is also the occurrence of some elements which were observed in isolated topaz samples; thus, No. 12 showed traces of zinc, No. 15—quite a considerable (app. 0.01%) concentration of nickel, and No. 19 a similar concentration of tin.

In comparing the data on the germanium concentration in topazes of various generation in all cases, when it is possible to establish the genesis

Germanium Content in Topazes

Sample No.	Deposit	Colour	Germanium content in %
1	Urals, Sanarka	yellowish	—
2	» »	violet	—
3	» Ilmen mts.	colourless, transparent	0.040
4	» » »	» »	0.038
5	» » »	» »	0.040
6	» Kamenka	» »	0.035
7	» Okulova Yama	» »	0.040
8	» » »	» »	0.040
9	» Lobachevsky mine	» »	0.024
10	» Prorok-Ilyinskaja	yellowish	—
11	» Alabashka	colourless, transparent	0.005
12	» Shaitanka	pale-yellow	0.024
13	» village Murzinka	colourless, transparent	0.037
14	» » »	» »	0.012
15	» » Lipovaya	sky blue	0.04
16	» Yujakovo	colourless, transparent	0.016
17	Zabaikalie, Borshchovochny range	» »	0.035
18	» Urulga	» »	0.015
19	» Yulovsky deposit	» »	0.015
20	» Adun-Cholon	» »	0.010
21	» » »	» »	0.010
22	» » »	» »	0.040
23	» Etykinsky deposit early	» non-transparent	0.020
24	» » » late	colourless, non-transparent	0.001
25	Ukr. SSR, Volyn	sky blue	0.003
26	» » »	green-blue	0.018
27	Zabaikalie, mt. Sherlovaya	colourless, transparent	0.002
28	» » »	» »	0.002
29	South America, Brazil	» »	0.0015
30	Germany	» »	0.004
31	Sweden (pyrophisolite)	» »	0.023

of the mineral, the following conclusion can be drawn. The germanium content may apparently serve as a diagnostic character, showing whether the topaz is of early or late origin; namely, topazes of early origin show a high Ge content, while the Ge content in topazes of later generation is considerably (10 to 20 times) less.

For the sake of comparison various beryls from the same deposits, as the topazes with the high Ge content (Emerald mines) were analyzed. Germanium was not observed in any of the beryls; but quite a considerable content of scandium (0.01%) along with a large quantity of chromium was observed in the green beryl. Chrysoberyl from this deposit contained a large quantity of gallium and a considerable quantity (0.1%) of tin. This concentration of tin in chrysoberyl should be compared with the high tin content observed by us a long time ago in micas and other minerals of pegmatite veins.

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GEOCHEMISTRY

CHARACTERISTICS OF WATERS OF UNDERGROUND LAKES

By G. A. MAXIMOVICH and G. G. KOBIAK

(Communicated by A. E. Fersman, Member of the Academy, 30. I. 1941)

Among the diverse lakes of the Globe, the underground variety is the least known. Even in detailed classifications of lakes they usually are not isolated (7). For the most part simply karst lakes are mentioned (3, 4, 6, 8, 9,). Still less has been studied the composition of the waters of underground lakes. W. I. Vernadsky (2) distinguishes among fresh corrosion waters of underground reservoirs (type 176, cavern waters) and underground salt lakes (type 282), referred for some reason to surface waters. This peculiar variety of lakes, the underground lakes, are however of considerable interest.

Of those known all over the world, the lakes of the Mammoth Cave in America, the lake of the 15.5 m deep Elrich Cave near Nordhausen should be mentioned. In the USSR there is also a number of underground lakes. In particular such lakes are known in the caverns of the Kizel (1) and Kungur districts of the Molotov region.

The present paper contains the results of a study of the composition of the water of the Kungur ice-cave lake. The chemical analyses have been made by G. G. Kobiak. Underground lakes in caverns are formed in hollows, in which the water is arrested by the accumulation of argillaceous material. Such conditions exist in the Kungur ice-cave, where 36 underground lakes have been found. From these the most accessible are the lakes in the grottoes Titanic and Coliseum, which are located in the part of the cave usually visited by excursions.

The area of the lake in the grotto Titanic is 750 m^2. Its depth is about 4 m on the average. The maximum depth recorded is about 6 m. The argillaceous layer in this grotto is about 1 m thick. According to the analyses of samples made at an interval of six years (see table, columns 1 and 2), the lake in the grotto Titanic should be referred to mineral (salt) lakes(2). The total of mineral constituents is above 2 g/l. Ca and SO_4 predominate in the dissociated part, which is quite natural for a cave in gypsum-anhydrite beds lying among limestones. Mg and HCO_3 are of lesser importance. A considerable SiO_2 (H_2SiO_3) content is noticeable.

A less complete analysis made by the physical-chemical laboratory of the Uralian Institute of Physiotherapy and Medical Hydrology (table, column 3) made in 1935 shows on the whole a similar picture.

The lake in the grotto Coliseum is of a considerably smaller size. The thickness of the clayey layer here is about 0.75 m. The water is also mineralized, the total of mineral constituents being even somewhat higher, 2.3349—

2.3360 g/l. The composition of the water varies very little, though the samples were taken at an interval of six years. It is to be considered that the samples have been taken in winter (table, columns 4 and 5). The prevalent constituents here are also Ca and SO_4. The lake in the grotto Coliseum is distinguished by a more than double Mg content and a somewhat smaller content of HCO_3, Na and Cl. The latter depends probably on that this lake is being visited much less frequently than that in the grotto Titanic.

Analyses of Underground Lake Waters

	Water of the lake in grotto Titanic			Water from the lake in grotto Coliseum		Water dripping from the cavern in Ethereal grotto
	1	2	3	4	5	6
Specific gravity of water at 20° C	—	1.00206	—	—	1.00237	—
Gram per liter:						
Dry residue of water at 110° C.	2.1812	2.1902	—	2.3349	2.3360	1.1734
Dry residue on ignition	2.0425	2.0373	—	2.1469	2.1571	1.0766
Loss on ignition	0.1387	0.1529	—	0.1880	0.1789	0.0968
Na	0.0019	0.0021	0.0391	0.0013	0.0015	0.0006
K	0.0001	0.0002	—	traces	0.0001	traces
Ca	0.5672	0.5669	0.4867	0.5456	0.5459	0.2654
Mg	0.0246	0.0244	0.0423	0,0579	0.0580	0.0346
Cl	0.0030	0.0035	0.0035	0.0017	0.0026	traces
SO_4	1.3630	1.3602	1.2970	1.4730	1.4717	0.7220
HCO_3	0.1200	0.1217	—	0.0801	0.0836	0.0546
SiO_2	0.0098	0.0100	—	0.0112	0.0110	0.0078
Al_2O_3	0.0023	0.0012	—	0.0021	0.0006	0.0017
Fe_2O_3		0.0003	—		traces	
Hardness in German units:						
total	85.05	84.96	—	89.70	89.77	45.14
removable	5.52	5.68	—	3.68	3.84	2.51
constant	79.53	79.28	—	86.02	85.93	42.63
Time of sampling	Dec. 1934	April 6, 1940	Oct. 15, * 1935	Dec. 1934	March 29, 1940	Dec. 1934
Analyst	Kobiak	Kobiak	Ovchinnikova	Kobiak	Kobiak	Kobiak

* Date of analysis.

In order to find out the cause of the mineralization of the lake, samples were taken of the water dripping in the Ethereal grotto from an organ pipe (table, column 6). This water is about half as much mineralized. It is to be considered that the water dripping in the Ethereal grotto reaches the cave through large caverns. These caverns are at the surface, while near the grotto there is an organ pipe of a considerable diameter (2 m). Owing to a rather rapid travel from the surface, this water is less mineralized. With a lower rate of travelling along the small hollows and fissures, the degree of mineralization would probably increase.

The fact that the lacustrine water is twice as mineralized as that penetrating along large caverns, may be accounted for by several causes. First, water showing a higher degree of mineralization penetrates into the lakes through

small fissures and hollows. Secondly, shores composed of clays and anhydrite contribute to additional mineralization of the lake water at the expense of dissolving of rocks. Some part belongs also to the evaporation of water from the lake.

The above data show, though on a limited material, that the waters of underground lakes of caverns in gypsum-anhydrite rocks are to be referred to mineral waters [salt waters, according to W. I. Vernadsky (2)]. W. I. Vernadsky refers the corrosional waters of underground basins to fresh waters. It is possible that in limestone caverns there are fresh-water lakes indeed. This is to be verified.

To the underground salt lakes exemplified by Bakharden in Kopet-dag, should be added waters of underground corrosion lakes in gypsum-anhydrite rocks. The waters of underground lakes in rock-salt (5) may probably belong to brines.

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MINERALOGY

ON THE IDENTITY OF TANATARITE AND DIASPORE

By J. D. GOTMAN

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In 1925, near the village of Kairakty, Kustanai region in Kazakhstan, 120 km eastwards from the town of Orsk, Petrushkevich (2) found in a chromite pocket a mineral which he described as a monoclinic variety of diaspore and named tanatarite. This mineral filled up small fissures in the chromite.

From a description of the newly found mineral made by Petrushkevich (2) and Tanatar (3) it may be seen that, as to its chemical composition, physical, optical and pyrognostical properties, as well as the thermal curve of water isolation, it is identical with normal rhombic diaspore; according to the authors' data, the optical orientation of the mineral was the only evidence of its belonging to the monoclinic system. The authors' data as to the oblique extinction of individual sections of the mineral lack clearness and are rather contradictory, thus giving rise to some doubt; and when the present author was invited to give a description of this mineral for the third volume of the «Minerals of the USSR» (published by the Academy of Sciences), he soon realized that first of all it was necessary to verify whether the mineral really belonged to the monoclinic system.

The mineral could be found in the Mineralogical Museum of the Ordzhonikidze Geological Research Institute, Moscow, which received it from I. I. Tanatar in December 1927. The portion of this mineral put at the author's disposal by the courtesy of N. A. Smolyaninov, from its external appearance corresponds exactly to the description given by Petrushkevich (2). The results of an examination made with the Fedorov stage and plotted on a Wulff net allow us to make the following conclusions:

1) The optical axes plane, i. e. the *Ng Np* section, is lying in the plane of perfect cleavage.

2) Beside the plane of perfect cleavage, the mineral shows two more equivalent planes of imperfect cleavage intersected with the former plane at a point which is at the same time the projection of the *Np* of the indicatrix. The divergence of the points of intersection of the two planes of imperfect cleavage from *Np* is 2°, i. e. within a tolerable error of the method.

3) The two planes of imperfect cleavage are arranged symmetrically with regard to the indicatrix axes, forming oblique angles with *Ng* and *Nm*.

4) In the section parallel to the plane of optical axes the extinction is direct with regard to imperfect cleavage.

5) The angle between the pole of perfect cleavage plane and the poles of the two imperfect cleavage planes is 68° and 180—114 =66°, giving the mean value 67°.

From the data obtained, we are obliged to admit that the mineral belongs to the rhombic system: the perfect cleavage is the pinacoidal cleavage, and according to Nikitin [1], it belongs most probably to (010). The two other cleavages are prismatic, and the Np-axis coincides with the [001] axis of the mineral. All this is characteristic of the normal rhombic diaspore, the perfect cleavage plane of which is that of (010), the prismatic cleavage plane that of (210) and the angle between the faces, along which the cleavage of diaspore is observed $(210) \wedge (010) = 64°53'30''$. The angle 67° measured between the cleavage planes of the mineral differs from the true angle by 2°, which may certainly be referred to the error of the method.

It should be noted by the way that in such cases when diaspore shows a tabular habit along (010), as it is the case in our mineral, its elongation in the section $\perp Ng$ is negative, while in the section $\perp Np$ it is positive.

Aside from the measurements on the Fedorov stage, M. I. Zakharova has taken a powdergram of our mineral which was found to coincide perfectly well with that of the diaspore from Kossoi Brod.

Conclusions: 1) The mineral found by O. A. Petrushkevich near the village of Kairakty (Kazakhstan) and determined by him as monoclinic diaspore is a normal rhombic diaspore. 2) The mineral tanatarite does not exist as a mineral species.

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MINERALOGY

LAZULITE IN THE ANDALUSITE-SERICITE-QUARTZ ROCKS OF THE KONGUR-ALANGHEZ RANGE

By S. A. MOVSESYAN

(Communicated by A. E. Fersman, Member of the Academy, 27. I. 1941)

The mineral lazulite has been found by the author in the andaluzite-sericite-quartz rocks which are widely spread at the western slope of the Kongur-Alanghez range, near the town of Kapudzhick, in the Paragachai andalusite deposit.

In the geological structure of the area of this deposit are involved Eocene porphyrites (tuffs, tuffites and tuffaceous breccias subordinate to these) and a banatite and granodiorite intrusion penetrating these. The latter presents one of the phases of the extensive and complex Kongur-Alanghez pluton of Tertiary granitoids. In the peripheral portion of the banatite intrusion near the contact with porphyrites and their tuffs the basicity of the intrusive rocks gradually increases up to gabbro-diorites and gabbro.

The influence of the intrusion upon the enclosing volcanogenic rocks at the expense of an alteration of the latter, resulted in a formation of a clearly visible zone—an areal of contact-metasomatic rocks, from 200—300 to 1500 m in thickness. These rocks are represented chiefly by sericite-quartz formations, known in literature as «secondary quartzites»; along with these as subordinate varieties occur: quartz-sericite-andalusite, feldspar-sericite and essentially andalusite rocks. Prospecting work is now being carried on for andalusite rocks.

The contact metasomatic rocks are composed of the following minerals (in the order of decreasing frequency of occurrence): quartz, light-coloured micas (sericite and muscovite), andalusite, sillimanite, pyrite, rutile, K-feldspar, corundum, diaspore, haematite, zircon, lazulite, brookite (?) and biotite. From these diaspore, corundum, muscovite, lazulite, K-feldspar and rutile are encountered almost exclusively in andalusite hornfels.

The contact-metasomatic rocks of Paragachai have been formed as a result of contact metasomatism processes: of the action of magma fluids, somewhat after the formation of the banatite intrusion.

The fluids and hydrothermal solutions which penetrated into the zone of the fractured exocontact and affected the porphyrites which had already been somewhat altered (normal metamorphism) through complicated chemical reactions, resulted in the migration, redistribution and redeposition of the primary elements in new correlations. Concentration of Al_2O_3, SiO_2, K_2O and TiO_2 and elimination of Na_2O, CaO, MgO and MnO took place here. The possibility, however, is not excluded of a supply of certain quantities

of SiO_2 and Al_2O_3 from the magmatic focus. The development of muscovite and lazulite points to a supply of fluorides and phosphates by magmatic emanations.

Lazulite has been detected in contact-metasomatic rocks (secondary quartzites) only in some places. Most frequently it is encountered in essentially andalusitic and muscovite-K-feldspar-andalusite rocks as a subordinate rock-forming mineral. Its grains, up to 0.1—1.5 mm in size, frequently form small accumulations. Lazulite is often replaced by sericite both along the periphery of the grains (replacement borders) and along the cleavage and minute fractures.

Colour light-blue. Under the microscope shows a distinct pleochroism from transparent-white (along *Ng*) to slightly bluish tinges (along *Np*). Refraction indices: $Ng' = 1.634 \pm 0.003$; $Nm' = 1.625 + 0.003$; $Np' = 1.621 + 0.003$. Axial angle $2V = -70°$.

Cleavage poorly developed in two mutually perpendicular directions. The *Ng*-axis lies in one cleavage plane, while the second cleavage plane forms a small angle 5—6° with the former.

		Ng	*Nm*	*Np*
Cleavage	I	90°	36°	54°
»	II	85°	55.5°	35.5°

The analysis of lazulite made by Shumilo, analyst to the Institute of Geological Sciences of the Academy of Sciences of the USSR, shows the following chemical composition of this mineral*.

Oxides	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MnO	MgO	P_2O_5	Loss on ign. $+H_2O$	Total
Content	0.04	0.40	32.58	0.53	1.38	none	0.03	12.10	46.66	6.25	99.97

In accordance with the chemical composition the following formula is obtained: $1.00\,(Mg, Fe, Mn)O—1.01(Al, Fe)_2O_3 \cdot 1.03P_2O_5 \cdot 1.09H_2O$.

Lazulite is highly resistant to the acids HNO_3, HCl, H_2SO_4, H_3PO_4 and HF; in a mixture of any of these the crystalline lattice is attacked only after igniting the mineral at 500—700°; after this a greyish-yellow mass is obtained easily decomposed in acids, especially in a mixture of fluoric and nitric acids. Sulphuric acid (1 : 3) does not attack it, even under high pressure (about 32 atm.) or at high temperature (235°).

It is worth attention that lazulite was detected also in andaluzite-bearing secondary quartzites of North Armenia (Sisi-Madan and Shagali-Eliar deposits) which had been formed like those of Paragachai, as a result of interaction between the granitoid intrusion and porphyrites.

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* In spite of careful sampling, the analysis might have contained small admixtures of the sericite replacing lazulite.

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KRISTALLOGRAPHIE

DER ZUSAMMENHANG ZWISCHEN DER ÄUSSEREN FORM DER SACCHAROSEKRISTALLE, DER HOMOGENITÄT UND ÜBERSÄTTIGUNG

Von N. N. SCHEFTAL

(Vorgelegt von A. E. Fersman, Mitglied der Akademie, den 29. I. 1941)

Bei der Untersuchung des Wachstums der Saccharosekristalle haben wir einen engen Zusammenhang zwischen der äusseren Form der Kristalle und ihrer Homogenität entdeckt. Gleichzeitig wurde die Abhängigkeit dieser Eigenschaften von sehr geringen Konzentrationsveränderungen in der Nähe der Sättigungsgrenze festgestellt.

Die Saccharosekristalle $C_{12}H_{22}O_{11}$ gehören zur monoklinen Hemimorphie (L_2). Die Konstanten der Kristalle sind nach G. Vavrinecz (1): $a : b : c = 1.2518 : 1 : 0.89458$; $\beta = 102°55.24'$. Nach P. Groth (2) weisen die Saccharosekristalle folgende Formen auf: a (100), c (001), p (110), p' ($1\bar{1}0$), r ($10\bar{1}$), q ($0\bar{1}1$), seltener o ($1\bar{1}1$) und d (101), noch seltener ω ($\bar{1}\bar{1}1$). G. Vavrinecz (3) stellte an Kristallen, die sich aus wässrigen Lösungen ausgeschieden haben, ebenfalls f (210) fest. An den von uns erhaltenen Kristallen waren nur die Flächen: a, c, p, p', r, q, d, o und in einem Falle ω vorhanden.

Die in Suspension befindlichen Kristalle wurden aus einer unbeweglichen Lösung in einzelnen Kristallisatoren gezüchtet, welche je 5.5 Liter Lösung enthielten. Für eine Reihe von Experimenten waren die anfängliche Temperatur und die Kurve ihrer Erniedrigung völlig gleich. Der Unterschied war nur in der anfänglichen Konzentration, welche in sehr engen Grenzen schwankte. Trotzdem waren die erhaltenen Kristalle von verschiedener Homogenität und ihrer Form nach ungleich. Um den Zusammenhang zwischen der Formveränderung und der Homogenität festzustellen, wurden 43 solcher Kristalle mit einem Gewicht von 10 bis 225 g genommen. Es überwogen grössere Kristalle.

Die Kristalle wurden qualitativ in 5 Gruppen eingeteilt: ausgezeichnete, welche keinen Mangel haben; gute, welche einen geringen Mangel haben; befriedigende, welche bei einigen Mängeln genügend grosse reine Teile aufweisen; schlechte, welche keine reinen Teile von solcher Grösse haben, dass man sie benutzen könne, und, endlich, sehr schlechte, d. h. völlig unhomogene, welche eine Menge von Mängeln verschiedener Art haben.

Darauf wurde die Flächengrösse gemessen und der Prozent berechnet, den die Flächen einer jeden einfachen Form zur allgemeinen Kristalloberfläche bilden.

Die angeführte Tabelle enthält die für verschiedene Gruppen erhaltenen mittleren Grössen. In ihr sind ebenfalls die Indexe der anfänglichen Konzen-

Relative Entwicklung der einfachen Formen bei Kristallen von verschiedener Qualität
(nach mittleren Daten)

Qualität der Kristalle	Index der anfänglichen Konzentration			Aus wie vielen Beobachtungen ist das Mittel abgeleitet worden	Anteil der Flächen an der allgemeinen Kristalloberfläche in %								Verlängerungsindex k
	% des Zuckergehaltes in der Lösung	Übersättigungskoeffizient	Brechungsindex bei 20°		a (100)	c (001)	p (110)	p' (1$\bar{1}$0)	r (10$\bar{1}$)	q (0$\bar{1}$1)	d (101)	o (1$\bar{1}$1)	ω (1$\bar{1}\bar{1}$)	
	27													
Ausgezeichnete . .	73.65	1.021 (7)	1.4741	11	35.7	33.0	14.6	13.5	2.3	0.7	0.1	0.1	—	0.25
Gute	73.70	1.022 (5)	1.4743	11	32.5	31.3	15.6	14.0	4.8	1.1	0.4	0.1	—	0.30
Befriedigende . .	73.75	1.023 (2)	1.4745	7	28.7	29.6	16.8	15.5	7.6	1.2	0.3	0.2	—	0.33
Schlechte	73.80	1.023 (8)	1.4747	6	24.4	27.1	18.1	15.8	10.1	2.3	1.7	0.4	—	0.36
Sehr schlechte . .	73.85	1.024 (5)	1.4749	8	24.5	21.9	17.4	13.3	13.8	4.2	2.6	2.1	0.05	0.37

tration und der Verlängerungsindex des Kristalls (k) nach der Achse b gegeben. Der letztere wird aus der Formel $k = \frac{p}{b^3}$ abgeleitet, wo p—das Kristallgewicht in Grammen und b—die Länge der Achse b in cm ist. Der Übersättigungskoeffizient wurde durch Teilung der Konzentrationslösung durch die Sättigungskonzentration bei derselben Temperatur bestimmt.

Das äussere Aussehen der Kristalle illustriert Abb. 1, auf welcher die Typen ausgezeichneter, befriedigender und sehr schlechter Kristalle dargestellt sind. Auf Grund dieser Tabelle und der Beobachtungen des Kristallwachstums kann man hinsichtlich der Saccharosekristalle, welche aus einer unbeweglichen wässrigen Lösung herauswachsen, folgende Schlüsse ziehen:

1. Die Veränderung der Kristalle von schlechten zu ausgezeichneten zeigt das Streben zur Grenzform, welche nur aus den Flächen a, c, p und p' besteht (Abb. 2). Einzelne Kristalle aus der Gruppe der ausgezeichneten nähern sich stark dieser Form. Man muss sie als Grenzform ansehen, weil eine weitere Vereinfachung bei Beibehalten der für die Saccharose charakteristischen Flächen unmöglich ist. Die bildenden Flächen sind notwendig um ein geschlossenes Polyeder zu bilden. Da gleichzeitig mit der Annäherung an diese Form die Lösung sich der Sättigung nähert, kann man sie mit grosser Wahrscheinlichkeit für eine Gleichgewichtsform der Saccharosekristalle halten, welche aus einer wässrigen Lösung kristallisieren.

2. Die Reihenfolge der Saccharoseflächen, welche ihre relative Wichtigkeit feststellt, ist folgende: a, c, p, p', r, q, d, o, ω.

3. Die Homogenität der Saccharo sekristalle ist eng mit der Grenzform verbunden, und umgekehrt. In der weitaus grösseren Zahl der Fälle nimmt mit der Entfernung der äusseren Form der Kristalle von der Grenzform die Homogenität schnell ab, was auf Kosten der Entstehung von weniger wichtigen Flächen und der Vergrösserung

ihres Anteils an der allgemeinen Kristalloberfläche vor sich geht. In erster Linie entwickeln sich dabei die Flächen: *r* und *q*, weiterhin *d* und *o*.

4. Die Stellen einer anfänglichen Störung, obwohl sie fast stets an die Teile des Kristalls gebunden sind, an welchen untergeordnete Flächen entstehen, befinden sich trotzdem in den benachbarten Teilen der Hauptflächen. So beginnt die äusserlich ganz zufällig scheinende Beschädigung der Kristalle in der überwiegenden Mehrzahl der Fälle nach der Achse *b* vom negativen Kristallende aus, auf welchem die Flächen *q* und *o* entstehen, doch nicht von diesen Flächen aus.

5. Die Formveränderung geht als Regel der Homogenitätsstörung voraus.

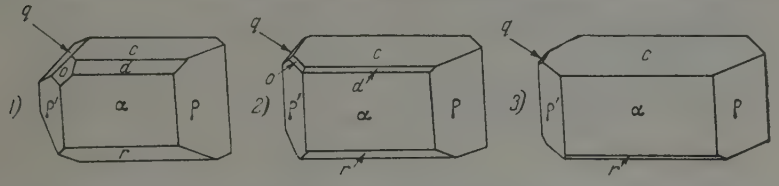

Abb. 1. Äussere Form der Saccharosekristalle: *1*—sehr schlechter, bei anfänglicher Übersättigung 1.024 (5) gewachsener; *2*—befriedigender, bei anfänglicher Übersättigung 1.023 (2) gewachsener; *3* —ausgezeichneter, bei anfänglicher Übersättigung 1.021 (7) gewachsener.

6. Der Übersättigungsintervall von 1.000 bis 1.021 (7) wurde nicht untersucht, da jedes Sinken unter die Grenzen 1.021(7) mit einer ungemein grossen Verlangsamung des Wachstums verbunden ist, doch in praktisch annehmbaren Untersuchungsgrenzen wird die Grenzform, wie auch die mit ihr verbundene Homogenität, in einem sehr engen Übersättigungsintervall verwirklicht. So macht der Intervall der anfänglichen Übersättigungen, welcher die ausgezeichneten und guten Kristalle einschliesst, nur 1.021(7) bis 1.023(2) aus; ausgezeichnete Kristalle wurden nur in den Grenzen geringer Schwankungen bei 1.021(7) erhalten.

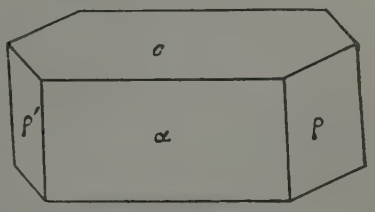

Abb. 2. Grenzform der Saccharosekristalle, mit Annäherung zu welcher die Homogenität zunimmt.

7. Gleichzeitig mit der Formveränderung und Homogenitätsabnahme verändert sich auch der Ausdehnungsgrad des Kristalls nach der Achse *b*, wie es die Veränderung des Verlängerungsindexes zeigt. Mit der Verschlechterung der Qualität und der Entfernung von der Grenzform werden die Kristalle kürzer.

8. Die gezogenen Schlüsse sind nur statistisch richtig, obwohl sehr selten Ausnahmen beobachtet werden.

Zur Erklärung dieser Tatsachen kann man E. Herlingers ([4]) Hypothese über die Konstitutionsmängel heranziehen, welche im Prozesse des Kristallwachstums auftreten. Die Wahrscheinlichkeit eines Auftretens der Mängel wächst rasch mit der Übersättigung. Durch ihre ungleichmässige Entwicklung können sie einen lokalen Wachstumsstillstand und eine Veränderung im Aussehen und Habitus hervorrufen. Indem wir diese Erklärung für unsere Tatsachen annehmen, müssen wir die äussere Form und Homogenität zu den strukturell-sensitiven Kristalleigenschaften rechnen.

Nach A. Schubnikoffs ([5],[6]) Beobachtungen an Alaunen besitzen sehr unhomogene, bei grosser Übersättigung gewachsene Kristalle eine symmetrischere und einfachere Form. Auf Grund theoretischer Betrachtungen und des

Studiums von mineralogischem Material schreiben Herlinger und W. Kleber[7] den Kristallen mit maximaler Konzentration der Konstruktionsmängel eine im wesentlichen nur von den Hauptflächen gebildete Form zu. Folglich verläuft die Veränderung der äusseren Formen, in Abhängigkeit von der Übersättigung, augenscheinlich von den äusserst einfach fazettierten und homogenen Kristallen zu den komplizierten und unhomogenen und weiter zu den unhomogenen und wieder der Form nach einfachen Kristallen.

Ein Teil der gezogenen Schlüsse wird wahrscheinlich für Kristalle vieler Stoffe zutreffen. In diesem Fall kann man annehmen, dass die Form der Kristalle, da sie eng mit der Homogenität verbunden ist, den Geologen als ein Merkmal bei Nachforschungen dienen kann. Zum Beispiel könnte für den optischen Fluorit die Würfelform der Kristalle als Merkmal bei Nachforschungen dienen.

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STRATIGRAPHY

ON «CYCLICITY» IN THE DEVELOPMENT OF TERTIARY FAUNAS

By V. P. KOLESNIKOV

(Communicated by A. A. Borissiak, Member of the Academy, 12. I. 1941)

The stratigraphy of the Tertiary deposits of the Ponto-Caspian region has been worked out in the main by N. I. Andrussov. It was he who described the majority of molluscan species occurring in these deposits. However, some of the conclusions of Andrussov regarding the development of faunas and basins call for revision. Among these is the view held by numerous geologists and paleontologists on the cyclic development of the Tertiary faunas of the Ponto-Caspian region. It has been formulated by Andrussov ([1]) as follows:

«Faunistically these deposits can be subdivided into 3 cycles, each of them showing gradual impoverishment of the fauna in upward succession.

Cycle I. Tarkhan horizon—marine fauna. Chokrak horizon—somewhat impoverished fauna (Euxine type). Karagan (Spaniodont) horizon—fauna greatly impoverished, comprising very few species (increase in salinity).

Cycle II. Konka horizon, presence of few pure marine forms (*Corbula*, *Aporrhais*, *Turritella*)—development of the Sarmatian type of fauna. Bessarabian horizon—typical and abundant Sarmatian fauna. Khersonian horizon—fauna strongly impoverished (increase in salinity?).

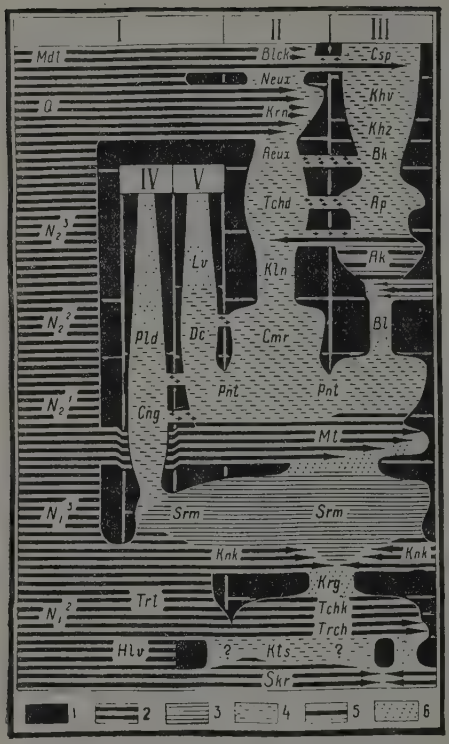
Cycle III. Lower Maeotic beds (semimarine fauna of the Sarmatian type). Middle Maeotic beds—growing poorer in marine elements. Upper Maeotic beds—diminutive *Congeria* and small-sized *Hydrobiidae* and *Neritidae* evolving (lowered salinity)».

The faunal succession is described by Andrussov correctly, however, his conclusion about cyclicity is erroneous. Such might be the conclusion arrived at when treating the Ponto-Caspian region individually, leaving aside its connexion with the adjoining regions. However, when considering the Ponto-Caspian region as part of the Neogene ocean, at times isolated, at others—united with it, there can be no question of cyclic development of faunas.

The development of fauna took a much more complicated course. Some idea about it may be gained from the scheme of development of Neogene and Quaternary faunas of south-eastern Europe, based on new data obtained during the last twenty years by Soviet paleontologists and geologists.

The scheme shows migration (arrows), faunal succession in various regions (hatched). Isolations of basins are marked in black.

Andrussov([1]) believed that there was a sequence in the development of the marine faunas of his three cycles and «that during faunistic intervals, corresponding to the Karaganian and Khersonian epochs, it was not that the faunas of the lower and middle epochs of the cycles disappeared entirely, but that *they survived somewhere*» (italics by Andrussov).



Scheme of development of Neogene faunas. I—Mediterranean region, II—Black Sea region, III—Caspian region, IV—Middle Danubian region, V—Lower Danubian region. *1*—isolation, *2*—fauna of the Mediterranean type, *3*—fauna of the Sarmatian type, *4*—fauna of the Caspian type (hatched in the same manner, but with a question mark the pseudo-Caspian type is shown), *5*—fauna of the Akchagyl type, *6*—fresh water fauna.

Indices (arranged alphabetically): *Aeux* — old Euxine beds, *Ak*—Akchagylian stage, *Ap*—Apsheronian stage, *Bk*—Baku stage, *Bl*—Balakhany stage, *Blck*—Black Sea, *Cmr*—Cimmerian stage, *Cng*—Congerian beds, *Csp*—Caspian Sea, *Dc*—Dacian stage, *Hlv*—Helvetian stage, *Khv*—Khvalynian beds, *Khz*—Khazarian beds, *Kln*—Kuyalnik stage, *Knk*—Konka beds, *Krg*—Karagan beds, *Krn*—Karangatian beds, *Kts*—Kotzakhuri beds, *Lv*—Levantine beds, *Mdt*—Mediterranean Sea, *Mt*—Maeotic stage, *Neux*—neoEuxinic beds, N_1^2—Middle Miocene, N_1^3—Upper Miocene, N_2^1—Lower Pliocene, N_2^2—Middle Pliocene, N_2^3—Upper Pliocene, *Pld*—Paludina beds, *Pnt*—Pontian stage, *Q*—Quaternary deposits, *Skr*—Sakaraul beds, *Srm*—Sarmatian stage, *Tchd*—Tchaudian stage, *Tchk*—Tchokrak beds, *Trch*—Tarkhan beds, *Trt*—Tortonian stage.

Investigations carried out during the last years do not support the conclusion on the succession of the Tarkhanian, Konkian ([3]) and Maeotic([4]) faunas, but at the same time do not refute their affinity. They descended from common or closely allied species of the Mediterranean, which were intruding the Ponto-Caspian basin during the period of disturbance of isolation (Tarkhanian. Konkian, Maeotic).

The succession of faunas within Andrussov's cycles is not to be explained by the survival of one and the same fauna taking refuge somewhere, while the unfavourable conditions lasted, but rather by successive migrations of Mediterranean species into the brackish waters of the Ponto-Caspian basin. The succession of migrations was due to local conditions of development of the basin—chiefly to movements of the earth's crust, which determined to a great extent the re-establishment and disturbance of the isolation of the basin ([2]). Thus, for instance, in the region of Danube (cf. scheme) where different local conditions prevailed, no «cyclicity» in the development of the identical fauna is to be seen.

Let us draw a more detailed comparison of the development of faunas of the Ponto-Caspian and Danubian regions. During the latter half of the Sarmatian these regions were isolated from each other. In the Ponto-Caspian region a peculiar Upper Sarmatian Mactra fauna started developing, which perished later on with the incursion of waters of higher salinity of the Maeotic transgression. This transgression did not penetrate into the Danubian, or, more precisely, into the Middle Danubian region. The basin situated there was isolated both during the latter half of the Sarmatian and during the Maeotic age. However, in this basin

began developing not the Mactra fauna, as in the foregoing case, but the so-called Congerian. Let us trace its further development.

While in the Ponto-Caspian region the Maeotic sea was on its way toward extinction (beginning of isolation and freshening), the Congerian fauna showed quite luxuriant development in the isolated Middle Danubian region. With the restoration of the communication between these two regions, representatives of the Congerian fauna well adapted to life in a brackish water basin, entered the extensive Ponto-Caspian region, where they developed into a peculiar Pontian fauna.

Toward the end of the Pontian age the basin was divided into several isolated parts. In the Lower Danubian region started developing the Dacian, in the Black Sea—the Cimmerian and in the Caspian—the Babadjanian fauna. Owing to a high increase in salinity, the Dacian and Babadjanian faunas died out, whereas the Cimmerian fauna partly survived and went on living in a modified form in the Black Sea region during the Kuyalnik age, i. e. at the time when the wide Akchagylian transgression swept over the Caspian region and carried with it a fauna alien to the South Russian Pliocene, some of its representatives having invaded the Black Sea region at the close of the Akchagylian. The Kuyalnik species (*Dreissensia*), in turn, penetrated into the Akchagylian Sea which was beginning to freshen, having almost entirely forced out the representatives of the native fauna, except some *Cardiidae* and small-sized gastropods.

Thereafter the Black and the Caspian Sea basins underwent more than one transitory connexion and exchanged some of the representatives of their fauna (the Apsheronian and Baku epochs), but on the whole the faunas populating these basins differed appreciably from each other, though it was bearing the so-called Caspian character.

During the post-Baku time the Caspian type fauna went on living in the Caspian region, whereas in the Black Sea region it was driven back toward the limans by the Mediterranean newcomers, of which *Cardium edule* penetrated into the Caspian region during the post-Khvalynian age.

Tracing the development of the Caspian fauna, beginning from the Sarmatian age (Congerian beds) up to the present time, we have recorded many examples of the local influence to which the fauna of isolated basins was subjected. If one should consider each of the basins separately, one may find many instances of allegedly «cyclic» development, but on taking all the basins together, there is revealed a very complicated picture of development. Elucidation of further details will greatly contribute toward the building of a sound theoretical basis for the stratigraphic schemes.

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STRATIGRAPHY

ON NEW CALCAREOUS ALGAE FROM LITTLE KHINGAN

By A. G. VOLOGDIN, Corresponding Member of the Academy

Until very recently no organic remains have been reported from the components of the ancient deposits making up the massif of Little Khingan, although investigation of this region of vital importance for the Far East was begun a long time ago.

Large scale research work was conducted here only since 1929. From that year on, alongside of important data on iron mineralization of Little Khingan, material has been obtained on the stratigraphical division of deposits. On ground of faunal evidence was separated the Permian, and material was accumulating for subdividing of the ancient metamorphic series, both according to lithological data and their interrelation with the normal section. Owing to contributions of numerous scientists, mainly from the Far Eastern (Khabarovsk) Geological Service, as well as those from the Leningrad Scientific Geological and Prospecting Research Institute, it has been possible gradually to arrive at an agreement upon the geologic section of ancient deposits of Little Khingan and to distinguish within this column deposits of the Archaean, Lower and Upper Proterozoic. The most complete record of geological data on Little Khingan was the one newly made by M. N. Dobrokhotov, who has carried on work here since 1936.

Organic remains from the ancient deposits were first reported by Muzylev, as well as by Dobrokhotov. The latter points to their occurrence in beds of the Upper Proterozoic as «poorly preserved algae, which unfortunately are not to be considered as guide fossils» (1). However, it should be noted that such is the attitude often assumed toward ancient algal formations by field explorers studying ancient deposits, as somehow they are not inclined to regard algae as having any stratigraphic value. The section of the ancient deposits of Little Khingan, which received the most detailed and objective treatment on the part of Dobrokhotov, is frequently estimated by the latter, as far as the age of these rocks is concerned, rather conventionally. The correlation between some of the series has so far remained unclear.

The rocks of Little Khingan recorded by the author fall into 3 complexes, as indicated below. The Archaean comprises: the Amur orthogneisses, Sutyr granitoids and granite-gneisses of Goryachi Kluch. The Lower Proterozoic includes: 1) series of diorite, tourmaline-staurolite, fibrolitic schists and marbles; 2) Soyuzny graphite-bearing beds (Soyuzny settlement on the Amur river); 3) bimicaceous gneissose granites. The Upper Proterozoic includes: 1) lower carbonate series; 2) Iginchin shale series (Igincha river, tributary of the Murandava river); 3) Murandava dolomitic series (Murandava river,

tributary of the Bidjan river); 4) ore-bearing series of ferruginous hornfelses and jaspilites; 5) Londoko limestone series (Londoko st., Far East railway).

Above this complex of deposits in the section Dobrokhotov records a series of siliceous and carbonaceous shales and then the Khekhtsyr series of sandstones, schists and conglomerates. These two series are referable to the Paleozoic, the latter, faunally, to the Permian. The above-mentioned rocks are overlain with sharp unconformity by Paleozoic deposits. The age of the first Paleozoic series is not yet precisely known.

As may be seen from the above data on the composition of ancient rocks of Little Khingan, chiefly magmatic rocks have been referred to the Archaean and Lower Proterozoic. Rocks mostly of sedimentary origin are indicated not until the Upper Proterozoic, where at the base, in the middle portion of the section, and at the top are recorded beds composed of carbonaceous rocks. The series of sedimentary rocks referable to the Upper Proterozoic designated by Muzylev as the Khingan one, is characterized by relatively poor metamorphism. Metamorphic rocks appear rather as local manifestations near intrusions.

The lowermost portions of the Khingan series represented by the Lower Carbonaceous beds are composed of grey banded limestones, interbedded with schists. The limestones are in some places marmorized, graphitized and in others dolomitized. Thickness of the beds not indicated, organic remains not recorded either.

The overlying Iginchin sand and shale series is essentially composed now of greenish-grey and now of dark-grey schists of various composition: clayey-micaceous, carbonaceous-clayey, quartz-sericitic etc. Frequently sandstone intercalations are observed within the series.

The Murandava dolomite series, resting upon the Iginchin series, is composed of white, grey and pink massive dolomites. Occasionally the character of these rocks changes, apparently, along the strike. The thickness of this series is estimated at 400—500 m and for some regions up to 2000 m (according to V. N. Danilovich). With the dolomite of the series are sometimes associated deposits of magnesites due to hydrothermal processes and intrusive activity.

The ore-bearing series, higher up lying transgressively, but «with no marked angular unconformity» (M. N. Dobrokhotov, 1939) is composed of clayey, carbonaceous-clayey, siliceous-clayey and quartz-sericitic schists with ferruginous hornfelses and jaspilites. The latter are of economic value. Thickness of ore-bearing series 100—400 m. Owing to the occurrence of iron ores, the series has been in places quite thoroughly investigated. The uppermost parts of the Khingan complex under consideration are represented by the Londoko limestone series. The latter is represented exclusively by limestones of various colour and texture, often characterized by an odour of hydrogen sulphide when struck with a hammer. Thickness of series up to 1000 m.

S. A. Muzylev discovered in this series algal remains which have been referred by V. P. Maslov to *Chlorellopsis Reis* from *Schizophyceae* (2). The stratigraphical value of this form has not yet been ascertained. Therefore the question as to the age of the Little Khingan series mentioned above is so far decided by way of comparison with other deposits of similar character in the Far East, without taking recourse to paleontological evidence.

It would seem that the poor metamorphism of sedimentary deposits of the Khingan complex should call for a search of organic remains in the rocks of this complex, however, up to date no paleontological discoveries, except the find of the above-mentioned algae by Muzylev, have been reported from the area concerned.

And this is why the discovery in 1939 of organic remains in the Murandava series, in the middle portion of the Khingan complex, by the geologist R. J: Epstein, should be considered as an event of extreme importance. The organic remains have been found by Epstein in the region of the Novo-Ditursk locality, in the northern part of the Little Khingan iron-ore district. Examined in thin-sections, the dolomites proved to be represented by a considerable number of forms of calcareous algae, evidently, entirely new, unknown in literature. Some of these bodies are characterized by quite complicated structure, connected with relatively high organization of the thallus. All forms are of the rock-forming type and seem to have been widely developed in the given region in some or other proportion.

A preliminary study of this new paleontological material by means of transparent thin-sections showed a number of investigated varieties of limestone to be wholly of algal origin, the deposition of these limestones having, apparently, proceeded under conditions of algal banks. State of preservation of the carbonaceous substance of the thalli, and of the unfossiliferous compact carbonaceous rock developed in places, is fair. Texture is very fine-grained, often pelitic. Rocks of this nature are capable of retaining very fine details of structure. This is borne out by the majority of thin-sections made from these limestones.

The new algal material from the Murandava series requires special study, description and publication. These first collections will be sufficient to help us to reveal a number of forms of algae which will no doubt assume great importance at once in the correlation of sections of the Khingan complex for various regions of Little Khingan. Let it be noted that some of the algal formations of the region of Novo-Ditursk locality bear considerable resemblance to some of the algal structures from the ancient carbonaceous deposits of Gornaya Shoria (Mountains of Shoria). The latter, however, have so far been inadequately studied. They are Proterozoic—Lower Cambrian in age (?). This is still a matter of great controversy between various explorers.

For reasons stated above we now feel justified in maintaining that the Murandava, as well as Londokov series (with *Chlorellopsis Reis*) contain, among other components, organogenous limestones and dolomites deserving more careful field investigation, and this will undoubtedly soon lead to new discoveries of some or other kind of organic remains. Therefore in the course of field work to be carried out in 1941 it will be necessary to examine in detail the sections of the above-mentioned series.

By means of monographic studies of paleontological materials already collected by Epstein in 1939, and what is more, by way of new special collections from each stratum, it will be surely possible to find out the guide algae. New discoveries will evidently stimulate more extensive work on the stratigraphy of the ancient deposits of the Far East. As we advance in our studies of the ancient algae of Siberia and the Far East, we can cherish the hope that already in the near future we may be able to solve many problems concerning the correlation of stratigraphic sections, as well as the age of deposits entering into these sections. Toward this end it is necessary to accumulate material in all regions of the USSR, where ancient carbonaceous rocks are developed. The practical value of this work is now beyond any doubt.

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CYTOLOGY

PRODUCTION OF TETRAPLOID RUBBER-YIELDING PLANT, *TARAXACUM KOK-SAGHYZ* RODIN, AND ITS PRACTICAL BEARING

By M. S. NAVASHIN and HELEN GERASSIMOVA

(Communicated by A. A. Richter, Member of the Academy, 9. I. 1941)

The rubber-yielding dandelion, *Taraxacum kok-saghyz* Rodin, which had been discovered only about ten years ago, soon became the most promising source of high-grade natural rubber among others available in this country. However, aside from many outstanding advantages (high rubber content and quality; low proportion of resinous admixtures; possibility of extracting the especially valuable rubber-containing latex; possibility of using the wastes for manufacturing a valuable product, the alcohol; earliness; cold-resistance, etc.), it has a number of disadvantages. They are as follows: a long period of rest of the seeds and low energy of germination, small seed size, long period of fructification; the most grave disadvantage is the small root size and low yield of rubber. The above disadvantages are peculiar to a wild plant; and kok-saghyz in fact still remains a wild plant. These unfavourable characteristics of the plant hinder to solve the problem of domestic natural rubber supply which is of prime importance to the nation. It is quite natural, therefore, that breeding improved forms of kok-saghyz is regarded a work of great importance.

Among the improvements sought by breeders, the most important ones undoubtedly are the increase in root size and in the diameter of the milk vessels. The increase in the root size would increase the yield (which is too low as yet), reduce losses on harvest and facilitate the technology of rubber extraction; increased milk vessels would be of a still greater advantage, both in regard to the amount of rubber accumulated within the root and to the ease of rubber extraction; besides it would improve the quality of the product (1).

A very serious advantage is, further, the increased seed size, since it makes sowing easier and increases the chances for the survival of the seedlings at the critical first days of their life.

Our work on tetraploidy in kok-saghyz was based upon the assumption that the increase of all the organs of the plant due to tetraploidy might be made use of in improving kok-saghyz with regard to the characters pointed out above.

The first task consisted in working out a technique which would make it possible to produce tetraploids en masse; breeding work requires a large material to start with, since a few plants will never combine in them the whole set of desirable characters. In our previous paper (2) we have communicated

the method worked out by us. It consisted in a treatment of the roots with colchicine, followed by propagation by root-cuttings taken from the root system developed of the initial treated roots. Owing to the fact that the root can never retain chimeral structure and, besides, may be very easily made tetraploid, a great proportion of these cuttings develop into uniformly tetraploid individuals.

Treating seeds or overground organs leads to far less favourable and consistent results.

With the aid of our method we have produced a whole tetraploid population comprising more than a hundred of plants. This material was sufficient to prove the beneficial character of a number of changes produced by tetraploidy.

The tetraploid plants were in fact distinguished through their extraordinarily robust development, through large dimensions of all their parts, fleshy and relatively broader leaves, very large inflorescences, etc. Among the alterations caused by tetraploidy, the most material ones occurred in achenes and in roots.

Achenes of the ordinary diploid kok-saghyz have a weight from 0.3 to 0.5 mg each; those of the tetraploid plants proved to have twice that weight (from 0.7 to 1.0 mg). The general dimensions of the roots of the tetraploid kok-saghyz are also markedly greater. The extent to which the roots were enlarged could not be determined with a sufficient degree of accuracy, since we had at our disposal no material grown under comparable conditions. However, the very fact of the increase of the root size is beyond doubt, and this could be proved even by inspection of the youngest rootlets.

The most interesting property of the tetraploids from the practical viewpoint is the increased diameter of the milk vessels, which, as pointed out above, is ascribed great importance. The increase in diameter leaves no doubt as to its reality and is very significant. Our observations thus fully support the conclusions reached by A. A. Nichiporovich in his detailed anatomical studies on polyploids in kok-saghyz.

A small fraction of seeds collected from the initial plants was sown in the middle of June 1940 after having been chilled during a short time at a temperature from $+1$ to $+2°$C. The seedlings obtained greatly differed from the ordinary diploid ones in being very robust and having characteristically rounded cotyledons and especially leaves; the last character is so conspicuous, that it can serve to distinguish unmistakably between tetraploid and diploid seedlings when mixed together.

It should be noted, however, that the rounded leaf shape (resulting from an increase in the width/length ratio) is characteristic of all the polyploids in general; it is impossible, therefore, to distinguish between tetraploids and triploids on the basis of this character alone. The triploids were obtained by us in great numbers from seeds produced in the previous year by chimeral plants which were allowed to intercross freely with surrounding diploid plants.

We will not deal here with triploids; it should be noted only that owing to their unbalanced chromosome composition, they are highly sterile, which is, of course, unavoidable in all the autotriploids.

A cytological study of the plants grown from seeds planted, as noted above, in the middle of June has shown that tetraploids of kok-saghyz from the very beginning produce a rather uniform offspring. Thus, out of 230 plants in which the chromosome composition could be determined with certainty, 200 proved to be tetraploid (32 chromosomes), 16 plants were of the $4n-1$ composition (31 chromosomes), 11 plants had an extra chromosome (33 chromosomes), 2 plants had two chromosomes less (30 chromosomes) and one

plant possessed two extra chromosomes (34 chromosomes). One may conclude, therefore, that, although our material is not yet fully constant, the hereditary transmission of tetraploidy is high (only 13.7% of aberrant forms). The numerical chromosome aberrations occurring in the progeny of the tetraploids are directly connected with the manner of conjugation of the chromosomes which cause a certain amount of irregularities in chromosome assortment and, correspondingly, partial sterility. A number of tetraploid forms (e. g. barley, tomato) owe their high sterility to irregularities of chromosome assortment at meiosis. The tetraploid kok-saghyz proved to be a favourable exception, although fertility differed in different progenies. Thus, the number of filled achenes per head varied from 20 to 90 (and even more) in tetraploids, whereas in diploids it amounted only to 80. The best tetraploid plants, in respect to the filled achenes per head, even surpassed the diploids, however, there was present still a certain proportion of empty seeds, the high absolute number of good seeds depending on an increased number of florets per inflorescence.

The total number of achenes collected from an individual plant attained 2000; this amount, of course, ensures a rather high coefficient of propagation.

There is full reason to believe that fertility of tetraploids may be greatly increased by selection. As a matter of fact, the degree of fertility in tetraploids is known to vary greatly with the progeny, thus clearly showing its hereditary nature.

The nature of these differences in fertility still remains obscure; it is possible that they are produced by different degree of heterozygosity connected with incomplete chromosome homology resulting in conjugation by two instead of by four, or perhaps in a to some extent predetermined chromosome assortment. In other words, it is possible that the highly fertile tetraploids are, as a matter of fact, largely amphidiploids. This interpretation is supported by the fact that low fertility is usually typical of self-pollinated forms; the comparatively high fertility of the tetraploids in kok-saghyz which is a typical cross-pollinated plant is, therefore, not unexpected.

The tetraploid progeny grown from the first portion of seeds has developed normally in spite of the late date of sowing. Some of the plants have reached blooming and yielded seeds in the autumn. Another portion of seeds was sown in the beginning of August after chilling on ice during one month. Germination per cent and energy proved satisfactory: over 1000 plants were raised. There were found 101 aberrant plants (88 plants of the $4\ n \pm 1$ constitution and 13 plants of the $4\ n \pm 2$ constitution) and 637 regular tetraploids (the total proportion of aberrants being 13.5%).

The two lots of plants, after elimination of all the aberrants, will serve as source of seeds for further work. The total number of seeds collected in 1940 from tetraploid plants exceeded 100000; all of them will be grown in 1941 for breeding purposes. As a result of selection we expect to have in the autumn a quantity of seeds sufficient for growing an improved tetraploid population consisting of from 2 to 3 millions of plants.

In concluding we wish to point out an interesting phenomenon which raises hopes that tetraploid seeds will be of advantage over ordinary diploid ones when sown directly in the field. We have observed this summer many beautifully developed young tetraploid plants growing spontaneously from seeds which dropped on the bed from the mother plants; under similar conditions we have observed no spontaneous offspring from diploid plants either this summer, or in our previous work. It is possible that the ability of producing spontaneous offspring under unfavourable conditions depends on a

shorter period of rest of the tetraploid seeds and on a greater vigour and resistance of the resulting tetraploid seedlings.

From the data obtained one thus should conclude that the tetraploid kok-saghyz is a valuable material for breeding improved forms of this plant. Our final aim is to produce a tetraploid variety of kok-saghyz possessing better characteristics than any preexisting form.

The co-operation of G. M. Belajeva and A. F. Cherednichenko is appreciated.

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GENETICS

SEGREGATION IN HYBRIDS*

By J. J. KERKIS and A. A. LIAPOUNOFF

(Communicated by A. N. Kolmogoroff, Member of the Academy, 25. XI. 1940)

In his note (1) A. N. Kolmogoroff deals with the question of whether or not Ermolaieva's material on the segregation of peas is in accord with Mendel's scheme, which may be represented in the following terms:

1. The individuals under observation are of three groups of genotypes: *AA*, *Aa* and *aa*, the former two possessing the dominant character *A*, and the third, the character *a*. All of the first generation will be of the *Aa* type.

2. All of the *Aa* type form an approximately equal number of gametes of the *A* and *a* types, whose total number considerably exceeds the number of offspring. The progeny consisting of n individuals obtained in crossing $Aa \times Aa$, may with equal probability be ascribed to the union of the various pairs of gametes

$$(\alpha_{i_1}, \beta_{i_1}),\ (\alpha_{i_2}, \beta_{i_2}),\ \ldots,\ (\alpha_{i_n}, \beta_{i_n})$$

of any of

$$s = \frac{k_1!\, k_2!}{n!\,(k_1 - n)!\,(k_2 - n)!}$$

k_1 and k_2 representing the number of gametes formed by the parents, and α_i and β_i, the idividual gametes.

3. The viability of the individuals possessing the dominant character *A* is on the average the same as the viability of the individuals possessing the character *a*.

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* Note by A. N. Kolmogoroff. My note «On a New Confirmation of Mendel's Laws» (1) has given rise to criticism by T. D. Lyssenko (2) and E. Kolman (3).

T. D. Lyssenko is absolutely right when he maintains that no two plants can be quite identical in their hereditary qualities. There can equally be no doubt that the prime object of the geneticist and of the breeder is to hit upon the *variations* in the hereditary qualities of plants. In this connexion statistics should play a subservient, though important, part. Statistics makes it possible to calculate whether a given difference in the frequency of the manifestation of some character in two families is sufficiently great for us to confidently ascribe it to the hereditary qualities of the parents.

Should one of two families (of 200 plants each), for example, give 150 beardless and 50 bearded plants, and the other, 190 beardless and 10 bearded plants, statistics will in this case, in full agreement with Lyssenko, tell us that there are weighty reasons to believe that the smaller number of bearded plants in the second family is due to the hereditary peculiarities of the parents in this family.

Should the variation in the frequency of the occurrence of the given character be of a smaller extent, statistics will tell us that in certain cases variation may as well be explained as the effect of casual externals. Finally, if the variety in the frequency of the occurrence of some character in a large number of families proves to be such, as it should

In our present note we give an analysis of a case of segregation to which Mendel's scheme as set out above does not apply; however, the agreement between the results of statistical treatment and theory is reestablished, if we replace the assumption contained in part 3 of the scheme ($p_A = p_a$) with the assumption that the ratio of the probable viability (until moment of counting) of the individuals possessing character A and character a, respectively, can be expressed by the term

$$p_A : p_a = \theta$$

the ratio diverging from 1.

In this assumption the probability that the individual taken at random surviving up to the moment of counting will possess the dominant character is

$$p = \frac{{}^3/_4\, p_A}{{}^3/_4\, p_A + {}^1/_4\, p_a} = \frac{3\theta}{1 + 3\theta}; \qquad (1)$$

the probability that by the time the count is taken, there will be m dominants in a family totaling n individuals, is

$$P_n(m) = \frac{n!}{m!\,(n-m)!}\, p^m (1-p)^{n-m}.$$

According to our assumption, if n is large, the quantities

$$\Delta = \left(\frac{m}{n} - p\right) : \frac{\sqrt{p(1-p)}}{\sqrt{n}}$$

will obey the normal law of distribution with unit dispersion

$$P(\Delta \leqslant x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-\frac{\xi^2}{2}} d\xi. \qquad (2)$$

Presuming our assumptions 1 and 2 to be correct, we find in our case

$$\theta \sim 1.03.$$

We may state that in the 329 families examined by us the empirical distribution of the deviation of the $\frac{m}{n}$ frequency from

$$p = \frac{3\theta}{1 + 3\theta} \approx \frac{3.09}{4.09}$$

compares favourably with part 2 of Mendel's scheme (see below).

In our experiments we have crossed the normal grey *Drosophila* with the recessive mutation of a dark black body colour. On May 16,

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be under the effect of exclusively casual external circumstances, then the biologist, on the basis of the statistical data, will have to draw the conclusion that the effect of the hereditary differences is rather two small as compared with the casual fluctuations of frequency. In such a case it would be useless to expect good results from breeding families which have shown a somewhat higher frequency in the occurrence of the desirable character. It is such a case that Ermolaieva hit upon in her experiments (4).

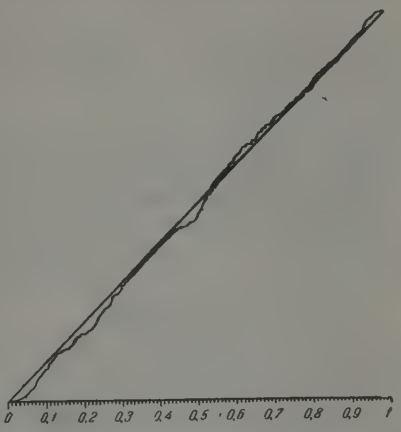
Hence, *in order not to fall a victim to blind chance, one should take into account the effect of casual factors and not confuse them with the effect of the hereditary peculiarities of the parents.* This is the lesson mathematical statistics teaches us.

In his note E. Kolman dropped the remark that some adherents of the Mendel-Morgan conception referred to my work as a «mathematical proof of Mendelism». Under no condition could my note give occasion for drawing such a conclusion. Along with E. Kolman I am of the opinion that Mendelism can be discussed only in the light of all biological and particularly cytological data. Equally true is the general proposition that no scientific hypothesis can be *proved* by mere statistics, for the same statistical relations may be explained by different hypotheses.

However, every scientific hypothesis, from which conclusions that lend themselves to statistical verification are drawn, may be statistically *refuted* if these conclusions dis-

1938, we crossed individually 17 virgin females of the dark black flies with an equal number of grey males. Of the 17 cultures obtained, 13 have developed.

The parent flies were left for 5 days in the jars and then removed. From each of the jars the virgin F_1 females were selected and each of them was crossed with a male of the same culture. To obtain a sufficiently numerous progeny from every couple of flies of the first generation, the flies were given fresh media every 4 days, the change of media being repeated three times. The average number of offspring obtained in this way totaled 199.6 in each family. To avoid losses of individuals due to ageing, counts were made daily until the material was fully exhausted. All the cultures developed on a standard quantity of food of a standard consistence, at a constant temperature of $26° \pm 0.5°$ C.



Our experiment embraced 329 families of the second generation totaling 75436 flies, of which 57014 were dominant and 18422 recessive. Thus, the ratio of the dominants was $\frac{57014}{75436} = 0.7558 \approx \frac{3.09}{4.09}$, quite good as a first approximation to Mendel's ratio 3:4. Our material, however, is sufficiently large for us to maintain that there is a slight consistent deviation from the ratio 3:4. Indeed, the deviation $0.7558 - \frac{3}{4} = 0.0058$ is 3.7 times larger than average quadratic error. The deviation being so wide, the probability of its having been occasioned by accident is quite negligible (0.0004).

Accepting the hypothesis of unequal viability while retaining assumptions 1 and 2, we get $p = 0.7558 \pm 0.00158$, or, according to formula (1), $p = 1.03 \pm 0.004$.

Proceeding from $p = 0.7558$, the normalized deviations were calculated for each family. Then

$$p(\Delta) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\Delta} e^{-\frac{\xi^2}{2}} d\xi$$

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agree with the results of observation. Thus, for example, in the note by J. Kerkis and A. Liapounoff, the authors quite properly refute by means of statistics the applicability of Mendel's pure scheme (with the assumption of the identical viability of individuals of different genotypes) to the material examined by them.

But when statistical verification shows, on the contrary, a fair *quantitative* coincidence with the conclusions that follow from a given hypothesis, while other competing hypotheses offer no possibility of predicting quantitatively the statistical relations observed, then we say that the hypothesis in question is statistically *confirmed*. Take, for example, the biological hypothesis about the chromosomal nature of inherited characters in peas with which I have dealt in my note. The result obtained was that inequality $|\Delta| < 1$ should on the average be observed in 68% of the families; actually Ermolaieva's experiments showed 67% in one of the series and 69% in the other.

Something should be said also about certain misunderstandings of facts to be found in E. Kolman's note:

1) He says that in my calculations I have discovered «an indication of an excessive approximation of the frequencies of $\frac{m}{n}$ to $^3/_4$» in Enin's data[5], while he without any cal-

is an accidental quantity subject to the rectilinear law of distribution on a section (0.1). In the figure are plotted the theoretical law of distribution—curve $y = x$, and the empirical law—curve $y = \frac{S(x)}{r}$, $S(x)$ being the number of families for which $p(\Delta) \leqslant x$, while r represents the total number of families.

Both curves run very close to each other, and the degree of their proximity may be accurately evaluated.

Applying Kolmogoroff's ([7]) criterion, we find

$$\lambda = 0.70.$$

To determine the divergence between the empirical and theoretical curves we get:

$$\Phi(\lambda) = 0.29$$

where $\Phi(\lambda)$ is the function, the table of which is given in the supplement to ([8]).

This shows that the divergence between both curves is quite admissible, i. e., that the assumptions set forth in part 1 and 2 of this note are quite acceptable and the deviation from Mendel's ratio 3:1 may be explained by the unequal viability of the respective types of individuals.

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Translated by V. Levin.

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culations found «the perfect, perhaps too perfect, coincidence between the empirical and the theoretically calculated frequencies» in other data given by Enin ([6]) relating to other experiments. However, as the calculations show, the deviations of the frequencies from $^3/_4$ in the materials to which E. Kolman refers, are not less than those Mendel's theory predicts.

2) E. Kolman finds that in the graphs given in my note the empirical curve constantly deviates from the theoretical one. In my note, however, it is pointed out that with the given number of observations this deviation is too small for us to draw any definite conclusions. The note on segregation in hybrids by J. Kerkis and A. Liapounoff contains considerably larger material and the authors have succeeded in *establishing* a small systematic deviation in the p probability from $^3/_4$. Allowance for the *possibility* of such deviations was also made in my note.

E. Kolman's arguments about arbitrary classification of characters would be of interest if only he took the trouble of finding out in each case whether the classification is really arbitrary or the difference between the two classes of plants is sufficiently well expressed and transitory forms are seldom met with. At any rate it may be taken for granted that Ermolaieva did not arrange her material so as to bring it in agreement with Mendel's laws.

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PLANT PHYSIOLOGY

CONDITIONS FOR THE OUTSET OF CULM FORMATION IN WINTER WHEATS COMPARED WITH THE CONDITIONS FOR SUCCESSFUL EARING

By K. A. SOROKIN

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The outset of culm formation is considered by many authors ([1–4]) as the crucial point in the development of plants. «If the plant has come into culm, its heading is only a matter of time»—write Maximov and Poyarkova ([2]), and on the basis of this statement they and Murinov ([1]), in calculating the heading ratio, reckon such plants among those which have already formed their ears. Dolgushin and Lyssenko ([5]), Čajlachjan and Alexandrovskaya ([6]) have put this phase, too, at the basis of their decisions on how the development of cereals is hastened by certain conditions. In a paper by Lebedintseva ([7]) we find the period between germination and stalk-shooting reported as the one, during which winter plants are the most sensitive to temperature and daylength. And finally, according to Razumov ([8]), Eremenko ([9]), Sapehin ([10]) and Ovechkin ([11]) coming into culm marks the end of the light phase.

The data presented here will bring out the differences between the conditions for stalk formation and for heading.

Winter wheat plants «Ukrainka» were planted in pots May 26, 1938. They were kept in the greenhouse until Sept. 26, when the lowering of temperature (minimum air $t°$, +5.1° C on Sept. 25; +6.4° on Sept. 26) made us to divide them into two groups. Those of the first, 114 plants in 32 pots, were taken to the hothouse. The second group numbered 126 plants in 32 pots, and these were placed on window sills in the laboratory. Minimum temperatures for the period from May 26, 1938 till Febr. 1, 1939 are referred to in Table 1, where the number of days is given, during which the respective temperatures prevailed. On Febr. 1, 1939 the plants in the hothouse joined those in the laboratory, and there all of them were kept until May 1939. From February to May the temperature in the laboratory was never under 14°C and usually ranged between 16 and 20° C.

Two of the plants came into culm as early as Sept. 25, while still in the greenhouse. From Table 2 it may be seen that no short day—the shortest day of December inclusive—could stop the process of culm formation.

Of 240 plants 181, or 75.4%, had formed culms at different dates between Sept. 25 and April 1; 33 plants had perished and the rest, 26 plants, came into culm later.

Table 1

Daily Minimum Temperatures

Place of observation	Time	Number of days, on which the particular minimum temperature was recorded																								
		0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°
Greenhouse	26—31 May	—	—	—	—	—	—	—	—	—	1	—	1	—	1	1	1	—	—	—	—	—	—	—	—	—	—
	June	—	—	—	—	—	—	—	—	—	—	3	5	2	6	3	5	3	3	—	—	—	—	—	—	—	—
	July	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	1	3	4	5	5	5	4	1	—	1
	August	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	3	7	4	7	3	5	—	1	—	—
	1—26 Sept.	—	—	—	—	—	1	1	—	—	1	—	—	—	1	4	3	3	4	2	1	4	1	—	—	—	—
Hothouse*	27—29 Sept.	—	—	—	—	—	—	—	—	1	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	October	—	—	—	—	—	—	—	—	3	1	3	6	6	5	—	2	—	—	—	—	—	—	—	—	—	—
	November	2	1	3	4	3	2	—	3	—	—	—	—	—	2	2	—	1	—	—	—	—	—	—	—	—	—
	December	1	2	—	2	3	—	—	—	3	1	2	7	3	—	—	1	—	1	—	—	—	—	—	—	—	—
	January	—	—	—	—	—	—	—	—	—	—	1	1	2	2	2	3	6	2	4	2	—	—	—	—	—	—
Laboratory*	27—29 Sept.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—
	October	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	9	11	—	—	—	—	—	—
	November	—	—	—	—	—	—	—	—	—	—	1	3	—	2	10	1	1	—	4	1	—	—	—	—	—	—
	December	—	—	—	—	—	—	—	—	—	—	—	2	2	1	4	8	8	1	—	—	—	—	—	—	—	—
	January	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	18	5	—	—	—	—	—	—	—	—	—
Hothouse set from May 26 till January 31		3	3	3	6	6	3	1	3	7	4	10	21	13	18	14	15	17	20	14	15	12	11	4	2	—	1
Laboratory set for the same period		—	—	—	—	—	1	1	—	—	2	4	11	4	12	26	36	24	24	26	25	12	11	4	2	—	1

* No records of temperature were taken on days off.

The culm formation, as is obvious from Table 2, was more intensive in the hothouse, where the temperature was lower and the light conditions appeared to be better. But in the laboratory, too, the plants that had remained alive all came into culm, though the temperature had been rather constant and high. From this flows the conclusion that culm formation is not prevented by either the absence of low temperatures or the influence of short autumn and winter days.

The conclusion is in full agreement with repeatedly reported observations of culm formation in the field by winter plants planted early in fall in the same year. Of one of such facts I have been informed by M. P. Khvastunov, manager of a seed-test laboratory in the Seversk district of the province of Krasnodar, who in 1938 had found winter wheats sown early in September at

Table 2

Culm Formation by Variety «Ukrainka» on Natural Daylength

Months	Hothouse			Laboratory			Two sets together		
	Culm formation (number of plants)		% of the total number of plants on Sept. 25	Culm formation (number of plants)		% of the total number of plants on Sept. 25	Culm formation (number of plants)		% of the total number of plants on Sept. 25
	in respective month	from beginning of the test		in respective month	from beginning of the test		in respective month	from beginning of the test	
September	1	1	0.9	1	1	0.8	2	2	0.8
October	17	18	15.8	20	21	16.7	37	39	16.2
November	27	45	39.5	18	39	30.9	45	84	35.0
December	18	63	55.3	10	49	38.9	28	112	46.7
January	30	93	81.6	15	64	50.8	45	157	65.4
February	9	102	89.5	0	64	50.8	9	166	69.2
March	1	103	90.4	14	78	61.9	15	181	75.4

the collective farm Schaumian to have formed culms before the advent of winter. But on the other hand, no case appears to have been recorded of a fall-planted winter wheat forming heads in the year of planting, however favourable might have been the conditions for it to do so.

And so our plants referred to in Table 2 would not form ears either, although they had managed to send forth stems containing 3 or 4 internodes and measuring 15 to 20 cm from the root crown to the upper node. But the stems formed on short daylengths eventually ceased growing, lost turgor and dried away. New ones appeared instead, which met with the same fate.

Failure to ear and dying away of developed stems might however be accounted for by the decrease in assimilation rate during the winter months, as has been pointed out by Maximov and Poyarkova (2). Merely by lack of plastic materials the plants might have been prevented from growing up and pushing the spike. To show that this was not the decisive factor, the data of another test are reported below.

On Febr. 1, 1939, part of the pots was set apart for photoperiodic treatment. In each of the photoperiodic sets there were two pots: one from the hothouse and one from the laboratory. Artificial light was supplied by an electric bulb of 500 W. The test lasted from Febr. 1 until March 21, 1939. As there was no significant difference between the plants from the laboratory and those from the hothouse in respect to the time of heading, there is no discrimination between them in Table 3 either.

Table 3

Exper. sets	Photoperiodic conditions from Febr. 1 till March 21, 1939	Outset of heading
I	Natural + electrical light by day, electrical light by night	Febr. 27
II	Natural light by day, electrical light by night	March 8
III	Natural + electrical light by day, no light by night	May 3
IV control	Natural photoperiods	April 16

From data of Table 3 it is obvious that earing is decisively affected by the duration of the light rather than by its intensity. Continuous illumination brought the plants to ear at the end of February (set I) or within the first ten days of March (set II), which was 26—35 days after the start of photoperiodic treatment. On natural spring daylengths the plants came to ear 1.5—2 months later: early in May (set III) and in the second half of April (set IV).

Electrical light when given by day, failed to produce any measurable effect upon the time of heading (compare I with II; III with IV). This in spite of the fact that the external appearance of plants was affected, and those in set III, compared to set IV, bore fresher leaves of a more intense colour and had made better growth.

Unlike culm formation, the phase of heading will not set in, unless the daily periods of light are long enough. In the case of winter variety «Ukrainka» there are reasons to put the minimum daylength required for heading at no less than 13—14 hours.

Thus, for winter wheat the difference between the two phases in respect to daylength is that one can proceed on much shorter daylengths than those which make possible the outset of the other. Therefore when these plants have come into culm, this does not mean that they are at the end of their light phase and do not require long photoperiods for further development. Such conditions are possible, when it would be an error to conclude from the fact of a plant having formed its stem that it is bound to form ears. The outset of culm formation must not therefore be considered as the critical period in the development of plants.

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PLANT PHYSIOLOGY

INFLUENCE OF TEMPERATURE ON THE RESPONSE OF *ARACHIS HYPOGAEA* L. TO DAYLENGTH

By A. I. CHELIADINOVA

(Communicated by A. A. Richter, Member of the Academy, 9. I. 1941)

Arachis hypogaea L., the common peanut, is a new culture in this country. The plant is remarkable for its high content of fat which amounts to 60% in the oven-dry kernel. Its introduction into the family of our crops brings us before the problem of adequate distribution. And of course, in confining the cultivation of this plant to certain districts, not only length of season, but also daylength is to be taken into account. Little is known as yet however about the response of *Arachis hypogaea* to daylength. The plant has been reported by different investigators now as a short-day one now as one of intermediate habit ([1–4]). I in my experiments ([5]) on two varieties of this plant found a 10-hour-day to have created the best conditions for development and flowering.

But the controversial statements in literature called for further research. So I started a series of tests against a background of varying external conditions. In the present paper the photoperiodic response of peanuts is considered with reference to temperature.

The first tests were carried on in Leningrad in 1936. The seeds of variety Spanish 0344 were planted in pots on June 5 and allowed to stand in the laboratory until germination (June 15). They were taken then to the greenhouse. There they received 6-hour, 10-hour and natural daylengths, respectively. As a result it was found that the date when the plants came to flower was not so much affected by short photoperiods, as was the intensity of flowering (Table 1).

Table 1

Experiments of 1936 at Leningrad

Daylength	Period between germination and flowering in days	Number of flowers per plant			Number of fruits per plant	% of fertilized flowers	Air dry matter in g	
		July	August	Total			fruit	green parts
6 hours	33	27	15	42	16.0	38.1	1.0	2.4
10 »	33	32	19	51	13.3	26.0	0.7	3.6
Control (natural day)	38	16	32	48	3.9	8.1	0.1	4.6

It is known of peanuts that all their flowers do not give fruit. About 50% remain usually unfertilized. What factors are responsible for this, has not been established as yet. Now it may be inferred from the tabulated data that the rôle of daylength here is very important.

While the plants treated with short days had 26—38% of their flowers fertilized, the long day treated had only 8%. Accordingly, the number of fruits was higher on short photoperiods. It may be remarked, however, that in the short-day plants, too, the ratio of fertilized flowers was lower than that usual for peanuts under natural conditions of growth. The reason might lie in an unfavourable influence of temperature under conditions of Leningrad. Further tests therefore were transferred to Krasnodar which is a natural station of this plant. They were run with the same variety, Spanish 0344. Planting was done at three different dates: May 27, July 24 and August 16, 1937. The plants were grown in pots dug in the ground. Those that served for controls received natural daylengths (15.5 hours of light in June, 12 hours in September). Special chambers were assigned to the short day treated. Part of the plants was given continuous illumination (additional light of 150 luxes).

The plants sown first were harvested October 6; the rest (second and third dates) October 14. Those first sown had come to grow under very unfavourable meteorological conditions. Their flowering had been delayed on account of low temperature prevailing at the early phases of development, while later too high a temperature (maximums between 35 and 40° C) had had a negative effect on their general condition. Even wilting would become apparent at noon: short-day plants suffered more from it than the others, for they received light in the middle of the day. They were therefore behind the controls both in the time and intensity of flowering (Table 2).

Table 2

Experiments of 1937 at Krasnodar

Daylength	Number of days from germination to flowering	Number of flowers formed during the season	Number of fruits per plant	% of fertilized flowers	Air dry matter in g	
					fruit	green parts
1st planting						
10 hours	37	55	30.7	55.8	11.2	12.1
Control	33	102	43.2	42.3	16.3	21.3
24 hours	33	98	37.4	38.2	14.7	20.7
2nd planting						
10 hours	22	91	27.5	30.2	5.3	13.4
Control	22	100	21.9	21.9	3.1	15.5
24 hours	23	101	24.8	24.5	2.9	18.4
3rd planting						
10 hours	29	23.6				
Control	32	12.3				
24 hours	32	11.0				

From Table 2 the number of flowers in the case of 1st planting is seen to have been nearly two times lower in the short day treated plants than in

the controls, or in the plants treated with continuous light. But the number of fruits was not very much lower, and the ratio of fertilized flowers was even higher.

The plants sown July 24 had better conditions for development. When in August the seedlings appeared above ground, they were to make further growth at a lower temperature (about 25° C) than that which had prevailed in July. But at the beginning of August the temperature was still high and made the plants come sooner to flower, so that in flowering these plants were 11—15 days ahead of those planted earlier. This time the plants in different sets came to flower simultaneously and the intensity of flowering was also the same (Table 2). But with equal number of flowers on short day trea. ted and long day treated plants the ratio of fertilized flowers was different. It was higher in the former, and so were the number and weight of fruits. Pod formation mainly accounts for this.

The plants sown August 16 could be observed only for first appearance of flowers and during a short while afterwards—from September 16 till October 10. Among these sets the short day plants had come to flower somewhat earlier than the other and showed higher intensity of flowering (Table 2).

To sum up, here as in Leningrad the effect of short photoperiods was slightly to hasten and increase flowering. This is probably because there was no significant difference in the temperature conditions between the two series of tests.

The conclusion to be drawn from all these data is that no photoperiodic treatment will accelerate the development of this plant, unless temperature continues favourable during the period before flowering. But even then the effect is not strong. The most interesting point in the photoperiodic response of peanuts is the effect on the formation of reproductive organs: flowers and fruits. We have seen here the number of flowers on the short day treated plants to vary according to the temperature. It can be higher, equal or even lower than in the plants that have made their development on longer photoperiods. But the ratio of fertilized flowers is always higher in short-day plants.

Additional observations on the formation of genophores in plants treated with short photoperiods and in plants grown on long natural days in Leningrad, showed that on the former the first flowers were already fertilized, while the latter gave only barren flowers during the first 10 days.

The ratio of fertilized flowers increases with the temperature. In our experiments it was more affected by temperature than by daylength. It was two times as high at Krasnodar (Table 2) as at Leningrad (Table 1) in the case of short day treated plants, although the number of flowers was equal. A similar relation is observed when plants of the 1st and 2nd planting at Krasnodar are compared (Table 2). The yield of fruit is increased considerably under conditions set up by a higher temperature.

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PLANT PHYSIOLOGY

SYNTHETIC ABILITY OF PLANTS AS AFFECTED BY VERNALIZATION

By I. N. KONOVALOV and T. M. POPOVA

(Communicated by A. N. Bach, Member of the Academy, 23. I. 1941)

The productivity of plants depends ultimately upon how runs the growth process and on their synthetic ability. In our previous works stretching over a period of several years ([1], [2], [4–6]) the yield of vernalized plants was studied in relation to growth. Now we shall analyze the material obtained by us in studying the question of the synthetic ability of vernalized plants.

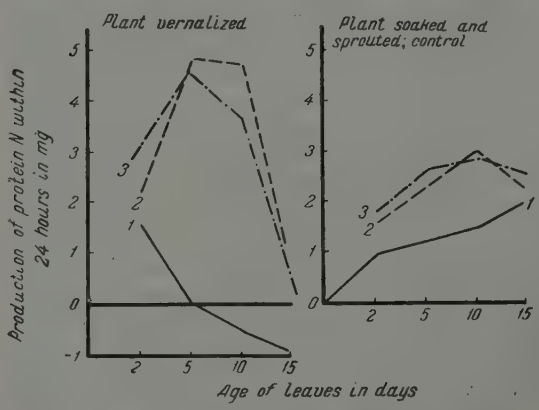

Fig. 1. Synthetic activity of protease in the leaves of spring wheat *Lutescens* 062 as affected by vernalization (estimations made by the method of floating leaves): *1*—1st leaf; *2*—4th leaf; *3*—6th leaf.

Three methods were used in this study. Decisions upon the synthetic power of plants were based on: 1) the accumulation of organic matter by them; 2) the formation of protein per unit time by their leaves when the leaves were kept in nutrient solutions (according to Schulze); 3) on their enzymic activity. The first method is the highest in precision, and it is therefore about the intensity of accumulation of organic matter that our interest has mainly centered. An integral expression for the synthetic power of a plant is obtained in that way, while the two other methods can furnish additional evidence only.

The work was carried on in 1939 and 1940. The plants involved were a semiwinter wheat *Apulicum* 685, and a spring wheat *Lutescens* 062. In order to follow up the accumulation of organic matter through various periods of development (tillering, stalk-formation, earing), 3—4 samples were taken at different times, each including 10 plants. This material was dried and weighed.

When the synthetic ability of plants was determined according to Schulze ([12]), the leaves were kept in a mixture of a 3% glucose with 0.4% ammonium nitrate for 24 hours. From the change in the amount of protein nitrogen after this procedure there was drawn the conclusion as to how great the synthetic power of leaves had been. Nitrogenous substances were estimated by the micromethod of Kjeldahl. The trend of enzymic activity was determined by studying the action of the invertase (saccharase). In estimating its synthetic action, the leaves were infiltered with a mixture of monosaccharides composed of equal amounts of glucose and fructose. And when the hydrolytic activity of invertase was determined, sucrose was infiltered in the leaves. These tests were run according to Kursanov ([7]).

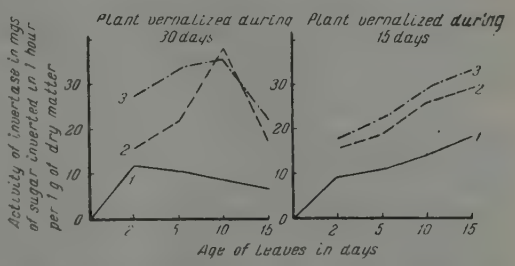

Fig. 2. Synthetic activity of invertase in the leaves of semiwinter wheat *Apulicum* 685 as influenced by vernalization (the same order of leaves as in Fig. 1).

As a result of the investigation we found that the presowing treatment of seeds had not failed to influence the synthetic ability of plants that had arisen from them. Namely, their synthetic power was higher than that of the unvernalized control plants. Towards the time of earing there was 26% more organic matter in them than in the plants from soaked and germinated seeds; and compared to the plants from dry seeds, the difference was even 52%. Similar data had been obtained in 1934 for lentil plants grown in the field ([2]).

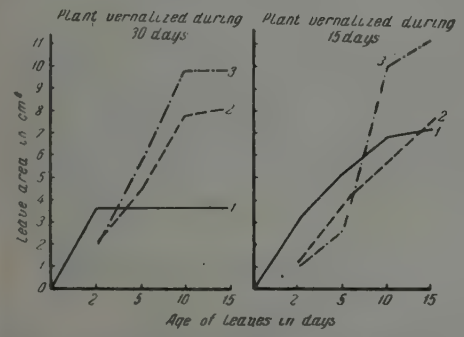

Fig. 3. Leaf growth intensity in semiwinter wheat *Apulicum* 685 grown from vernalized seeds (the same order of leaves as in Fig. 1).

This increase of synthetic power in response to vernalization is observed not only when the whole plants are compared as in Fig. 1, but also when reference to leaf area is made. Thus, on coming to ear the vernalized plants with their leaf area of 41 cm² had stored 34 g of organic matter; the controls from soaked and germinated seeds, bearing a leaf area of 38 cm², had stored 25 g; and the controls from dry seeds only 16 g, while their leaf area measured 26 cm². Referring the store of organic matter to leaf area we obtain 0.83, 0.66 and 0.61, respectively. It is the vernalized plants again that hold first place. This difference is observed when other phases previous to flowering are considered, though it is not so pronounced then. But after flowering has set in, the vernalized plants are very near to the end of their developmental cycle, and then the controls can sometimes catch up with them as regards the accumulation of organic matter. In droughty regions however this is very seldom the case. In practice therefore vernalized plants are always higher in organic matter.

This relation between the synthetic abilities of vernalized and unvernalized plants is supported by data on enzymic activity. The curves in Figs. 1 and 2 bring this out.

The synthetic action of enzymes in the leaves of vernalized plants rises from the very outset as the leaves develop until a maximum is reached, whereupon it begins decreasing. In the leaves of unvernalized plants the increase of synthetic action is slower and continues longer.

Such an enzymic behaviour is not a matter of chance. A parallel can be drawn between it and the leaf growth in the respective plants. The data on leaf growth for the semiwinter wheat *Apulicum* 685 are presented in Fig. 3.

When the leaves grow, grows also the synthetic activity of their enzymes until it reaches its maximum. Then a decrease takes place. So it is with vernalized and unvernalized plants. But the difference is that the process is more rapid in the former and the weakening of their synthetic ability is observed sooner. A higher hydrolytic activity of enzymes in vernalized plants has been reported also by Sisakian ([10]), Filippenko ([11]), Konovalov ([3]) and others. This course of the curve bringing out the synthetic ability of leaves is related to the course of their growth process.

Our former investigations and the data available in literature give ground to consider the acceleration of leaf growth and the reported changes of enzymic activity as one of the main reasons for the increased productivity of vernalized plants. These two processes set up favourable conditions for the development of the ear organs in such plants.

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PLANT PHYSIOLOGY

PHOTOSYNTHESIS IN PLANTS AT HIGH ALTITUDES

By O. V. ZALENSKY

(Communicated by A. A. Richter, Member of the Academy, 20. I. 1941)

Experiments made by Bonnier ([3], [4]) have shown that the activity of photosynthesis increases in the clones of plants grown at 2300 and 2400 m above sea level in the Alps and the Pyrenees. Plants taken from different heights and having a different structure of leaves were compared by him under similar external conditions. The increased rate of photosynthesis in the plants from higher stations for which the light factor was responsible, was considered by Bonnier as the reason why plants from a single clone had a different structure of leaves after being cultivated for a long time at different altitudes.

From the ecological point of view it is of interest to establish how the rate of photosynthesis varies according to the elevation in plants having the same structure of the leaf. No less interesting task is to trace the rate of photosynthesis in the plants grown as high as 4000—6000 m in the cold high desert of the Eastern Pamirs. This desert ([1], [2]) is notoriously dry and is distinguished by low temperatures and low concentrations of CO_2 in the air (about 0.3 mg/l on the average) as well as by strong insolation (1.66 cal. and higher).

With the help of a team of alpinists from Odessa headed by A. V. Bleshchunov, the author together with V. D. Kostenko made estimations of photosynthetic activity in plants at 3860 m and 6000 m above sea level, late in July and in August 1940. For that purpose plants of hull-less barley (*Hordeum vulgare* v. *hymalaiense*) and spring wheat (var. *Graecum* 289) were taken, while in the phase of stalk-formation, from the fields of the Chechetkin post of this station and planted into pots. The humidity of the soil in the pots throughout the experiment was 52—56% of its water holding capacity. When the plants had firmly established themselves and formed a dense net of young roots, they were tested for photosynthetic activity at a height of 3860 m. Then the pots with the plants were transported with every care to a height of 6000 m in the region of Ak-Baital pass, where a special camp and a field laboratory were organized for a period from the 1 to 10 of August 1940. Under these conditions the plants were tested 4 days after arrival (figure).

The method used in the tests was to draw the atmospheric air through a glass chamber containing a leaf not severed from the plant and through another chamber without leaf (control). Carbon dioxide was absorbed by *N* 25% solution of barite in the absorbers of Krasnoselskaya and Ordoyan ([5]). The titration of *N* 25% solution of HCl was made on the spot after the test.

Assimilation of CO_2 was expressed in mgs per 1 dm^2 of leaf area per hour. The concentration of CO_2 was reckoned in mgs per 1 l of air.

The figures in Table 1 refer to the tests made at 3860 m above sea level. With a concentration of CO_2 lying between 0.30 and 0.52 mg/l and a tempe-

Field laboratory at the Ak-Baital pass.

rature ranging from 9 to 17°C, the rate of photosynthesis in wheat amounted to 58.7 mg CO_2 per 1 dm^2 of leaf area. The respective figure for barley was 19.0 mg CO_2.

Table 1

Assimilation of CO_2 by Wheat and Barley at an Altitude of 3860 m (July 30—31, 1940)

	Start of test	Weather conditions	Air temperature	Psychrometrical difference	Concentration of CO_2 in mg/l of air	Assimilation of CO_2 in mg/dm^2 per hour	
						a	*b*
Wheat *Graecum* 289	7.48	Calm; clear	8.6	—	0.52	+ 5.2	+ 3.4
	10.26	Feeble wind; sun often behind light clouds	9.5	0.9	0.52	+ 58.7	+43.2
	14.40	Calm; clear	17.2	5.0	0.31	+ 32.6	+28.0
	18.38	Feeble wind; clear: sun behind the mountains	10.3	4.7	0.40	0.0	0.0
Barley hull-less	7.15	Calm; clear	7.2	2.9	0.52	+ 19.0	+15.4
	10.15	Feeble wind; clear .	19.0	6.0	0.35	+ 5.5	+10.2
	14.30	Feeble wind; clear .	13.2	8.3	0.30	+ 10.7	+16.5
	18.15	Feeble wind; sun behind the mountains	9.4	6.2	0.44	— 2.6	—

Daily changes in the rate of photosynthesis under the conditions prevailing in the Pamirs follow the course of a two-peak curve in the case of barley ([5], [7]). The first maximum always occurs in the morning, no matter if the temperature of air is very low at that time. For the Pamirs Blagowestschenski ([2]) has reported photosynthesis in barley at as low a temperature as—2° C, which followed a night frost of—8.5° C. The increased rate of pho-

tosynthesis in barley in the early morning hours may be linked with the increased concentration of CO_2 in the air, which is usually observed at that time. In the case of wheat the rate of photosynthesis runs, when depicted graphically, as a one-peak curve. The maximum falls within the afternoon hours which are characterized by positive temperatures. Here the temperature optimum for assimilation is higher than in the case of barley.

The results of the tests made at a height of 6000 m are presented in Table 2. Concentration of CO_2 in the air as measured just above the ground, showed fluctuations within 0.06—0.31 mg/l, according to the strength of the constantly blowing winds. The average values of the concentration of CO_2 may be supposed to lie between 0.09 and 0.16 mg/l. Measurements of the air temperature also revealed a very different picture from that observed at 3860 m. There it had been never below 0° C by night, when we have run our tests. Here it dropped to —8—12° C every night during the first ten days of August. By day, in face of strong insolation, the temperature seldom rose above + 5° C in the air, while 2 cm deep below the surface of the ground it reached +36° C. The fact of everything being strongly heated at the surface by direct sun rays must be taken into account as a potent factor in analyzing the physiological processes of plants. Thus, on August 9, 1940 at 12 h. 15 m., when the air temperature in the chamber was 4.8° C, the temperature of the wheat leaf proved to be 13.2° C.

Of 12 determinations made at the height of 6000 m 3 gave a clear-cut evidence of photosynthetic activity. In all the other cases the assimilation was nearly or completely absent. Of great interest are the short-lived peaks in the rate of photosynthesis which in the case of wheat amounted to 47.4,

Table 2

Assimilation of CO_2 by Wheat and Barley at a Height of 6000 m (August 7—10, 1940)

	Start of test	Weather conditions	Air temperature	Psychrometrical difference	Concentration of CO_2 in mg/l of air	Assimilation of CO_2 in mg/dm² per hour	
						a	*b*
Wheat *Graecum* 289	10.30	Moderate wind; sun behind light clouds	—1.2	—	0.28	0.0	0.0
	12.15	Moderate wind; sunshine . . .	4.0	4.8	0.16	+47.4	+32.3
	13.30	Feeble wind; sun behind light clouds	1.5	3.0	0.13	— 6.0	— 3.2
	15.10	Moderate wind; sun behind light clouds	—0.5	1.7	0.09	—11.0	—
Barley hull-less	8.00	Feeble wind; sun behind light clouds	0.4	0.4	0.06	0.0	—
	10.33	Almost no wind; sun behind light clouds	4.2	3.6	0.33	+ 8.7	+12.4
	11.09	Moderate wind; sun behind light clouds	6.8	5.2	0.12	+20.7	+21.1
	15.19	Very poor wind; clear	0.5	0.5	0.31	0.0	0.0
	17.21	Feeble wind; clear	—3.2	—	0.11	—33.0	—

in the case of barley to 21.1 mg of CO_2 per 1 dm^2 of leaf area. No direct relation can be established between the increase in the rate of photosynthesis and the increase in the concentration of CO_2 in the air. Apparently the deficiency of carbon dioxide cannot be offset by the light factor unless certain temperature conditions are available.

From the data reported here it may be assumed that under such conditions as prevail in the Eastern Pamirs at heights of the order of 6000 m, the assimilation of CO_2 by plants is not possible even during the warmest season, except some few days and then only within a very short time. This makes the life of higher plants impossible on those heights even in a congenial edaphic environment. It would seem therefore that natural vegetation, whose distribution in the Muskol range of the Eastern Pamirs does not go beyond a height of 5300—5500 m, is using to the limit all the possibilities for assimilation of CO_2, which are offered here to the plants by the complex of external factors.

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PLANT PHYSIOLOGY

DEVICE FOR MEASURING THE RATE OF PHOTOSYNTHESIS IN PLANTS

By A. A. NICHIPOROVICH and N. G. VASSILIEVA

(Communicated by A. A. Richter, Member of the Academy, 29. XII. 1940)

Very often in measuring the rate of photosynthesis it is essential to carry on several—at least two—parallel determinations at a time under strictly identical conditions on different objects. An attempt to meet this demand by a specially designed apparatus was made under the leadership of A. A. Richter at the Laboratory of Photosynthesis, Academy of Sciences of the USSR. The result was an experimental set-up, which later was described by one of these authors in an article reviewing the methods available for the study of photosynthesis ([1]). It was used in experimental work by N. G. Vassilieva during the summer of 1940. On the basis of that experience various modifications were introduced in the initial design, and in its ultimate form the apparatus proved very efficient and able to give data of considerable accuracy. We think it fit therefore to present here a new description of it and to show it in operation.

Fig. 1 is a general view of the apparatus. Its main parts are the absorbers of carbon dioxide (*7*) and the assimilation chambers (*2*) of A. A. Richter ([2]).

Aspirators usually employed for drawing the air through are replaced here by an oil pump (*17*) with a 0.25 kW motor and a system of rheometers (*10*). When the air is drawn through the capillary tube connecting the two manometric bends of the rheometer, a gradient of pressure is set up proportional to the rate of air flow along the passageway of the capillary tube. In other words, for a given rheometer to any gradient of pressure, as registered by the position of the mercury meniscuses, there corresponds a definite velocity of the air current. The latter can be regulated by locking screws (*11*), but it is better to use throttle or conical valves for that purpose. The rheometers are graduated and checked either against gas dial gauges, or against graduated petroleum rheometers which are more sensitive and accurate. Before the rheometers there are V-tubes with calcium chloride (*9*) to remove moisture out of the air and prevent its condensation in the capillary tubes. The inside diameter of the capillary tubes is 0.3—0.4 mm, and when the air current passes through a rheostate at a rate of 30 l per hour, the pressure gradient is 100—120 mm of the mercury column. Experience showed that the requisite gradient of pressure could easily be adjusted and kept up within an accuracy of 1 mm. Deviations in the velocity of the air current must not therefore exceed 1%. But this, of course, implies that the air should be driven through with a constant strength. To make the strength of draught

independent of occasional changes in the power of the pump, a vacuum magazine (*13*) with Bunsen's valve and a mercury regulation of pressure (*12*) are inserted in the system.

Since the pump sucks in more air than can be let through by all absorbers working together, part of it is admitted into the vacuum magazine by way of the regulator of pressure, passing which the air has to push through a mercury column 19 cm high. This determines the constant value of the vacuum in the magazine. If the mercury in the regulator of pressure is tossed by the air with too much vehemence, part of the air is let in through the locking screw (*12a*). But the screw is to be loosed to such an extent as not to stop the regular thrusts of air through mercury in the regulator of

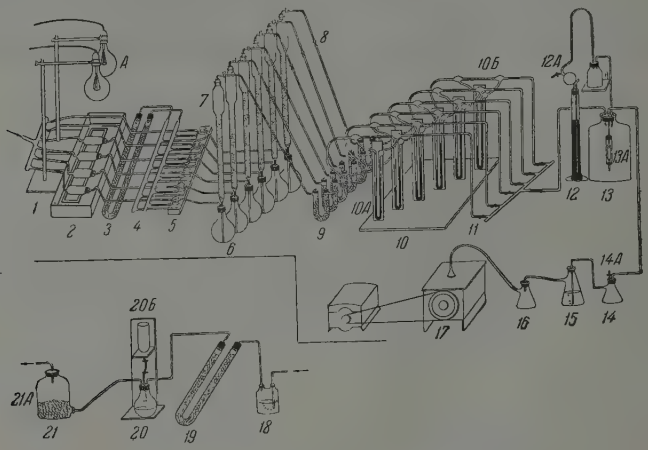

Fig. 1.

pressure. Before bringing the pump to a standstill at the end of operations, the clamp (*14a*) on a protective flask must be let loose lest oil should be thrown out of the pump.

To catch the mercury vapour there is a jar (*15*) filled with a mixture of 2% solution of permanganate and sulphuric acid. Since for every rheometer the velocity of the air current passing through it is not adjusted at once, it is necessary that the air should be free from carbon dioxide, until the requisite rate of passage is reached. Therefore at the start of operations it is let out from the assimilation chambers through a tube containing soda lime (*3*). At that time the position of the faucets (*5*) is the one indicated by *A* in Fig. 2. All of them are one by one quickly turned into position *B* as soon as the rheometers are adjusted. And they are brought back into position *A* in the same succession when the exposure is over. Before starting the run, when the faucets are yet in position *A*, the whole system must be tested for air-tightness. This is done by clamping the rubber tubes in different places (from 5 to 6, from 7 to 9 and from 9 to 10). Now if the system is air-tight, the mercury meniscuses in the respective rheometers will go down to zero or to 1—2 mm.

Work is greatly simplified by the following details. Instead of Bunsen flasks the absorbers are connected with flat-bottomed flasks 200—250 cm^3 in volume (*6*). During exposure the alkali is drawn from the flask into absorber through a glass tube whose lower end reaches the bottom of the

flask, while its upper end is connected with the absorber by means of a rubber tube(4). When the experiment is over, the alkali is forced back into the flasks by pumping carbon dioxide free air into the absorbers through their upper ends. The absorbers are then washed with water deprived of carbon dioxide, too. After washing a new set of flasks filled with alkali can be connected to them. The procedures of filling the flasks and titration are to be run in accordance with the indications given by A. A. Richter (2).

Into all chambers an air of the same composition is drawn through a common comb. In many respects it is convenient to have the content of carbon dioxide in the air adjusted beforehand, but not adjusted to a single level. For that reason the air while on its way to the distribution comb has to pass a purification-concentration system (*18—21*) described in substance by K. Purievich (3). In our case this system consists of: 1) a jar with an acid solution of permanganate, which serves for purifying the laboratory air from organic admixtures and ammonia (*18*); 2) a V-tube (with each of its bends 50 cm long) containing soda lime for the absorption of CO_2 (*19*); 3) a concentration flask with 5 cm³ of a strong solution of H_2SO_4 into which drops of soda lime are falling during the experiment (*20*); by varying the rate of dripping (between 20 and 40 drops per minute) as well as the concentration of soda, it is possible to adjust the mixture to a desirable composition with a certain degree of precision; 4) and finally a jar filled with glass beads (*21*) serves for mixing air with carbon dioxide.

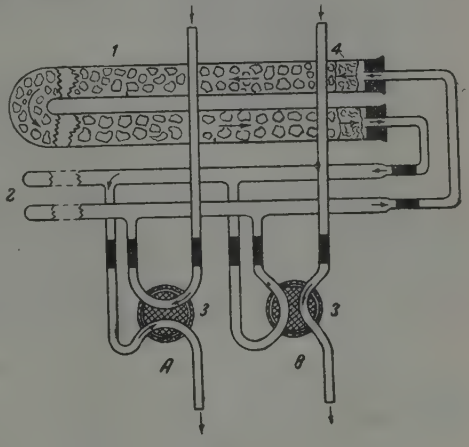

Fig. 2.

It must be noted, however, that with the insertion of this system it still remains necessary to switch in two control absorbers in order to analyze the composition of the initial air.

Numerous tests by N. G. Vassilieva have shown that if all parts of the apparatus are properly adjusted, its work is so precise as to make possible the most accurate estimations of photosynthesis. Parallel titrations of alkali from the various absorbers after air of the same composition has been passed through them, show absolute coincidence. Nearly as close to one another will lie the data of parallel estimations of photosynthesis, especially if the advice of A. A. Richter is followed and the leaves to be tested are shaped into pieces of equal area. Here are two examples of parallel tests made by N. G. Vassilieva.

Horse been leaves	Photosynthesis (mgs of CO_2 per dm² per hour)			
	Test 1, a	and b	Test 2, a	and b
Whole, with subsequent determination of their area	18.0	19.2	17.0	19.3
18 cm² leaf pieces	18.27	18.27	18.03	18.03

It has been found by experience that when the air flows at a rate of 30 l per hour, the leaf area in the chambers must not exceed 20 cm². If it is larger than that, the leaves must be protected from starvation either by increasing the content of CO_2 in the air or by giving more speed to the current.

The efficiency of the apparatus is quite satisfactory. In the space of a working day 3—4 cycles of measurements can be done by one person, if the leaf samples are to be exposed for 2 min. Two 1000-W bulbs bring to the leaves an illumination intensity of 20000 luxes. To obviate overheating the chambers are placed in a bath filled with water.

It is possible to control: a) the intensity of illumination by shifting or screening the lamps; b) the thermal regime by varying the temperature of water in the bath; c) the content of CO_2 in the air current. And if we take moreover into account the considerable productive capacity of the apparatus and the high accuracy of its work, it will be apparent that it goes far in making more easy and perfect the study of so an important function of plants as is their photosynthetic activity.

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PLANT PHYSIOLOGY

ATROPINE TRANSFERENCE FROM STOCK *(DATURA STRAMONIUM)* TO SCION *(SOLANUM LYCOPERSICUM)*

By S. J. KRAJEVOJ and I. NECHAEV

(Communicated by A. A. Richter, Member of the Academy, 19. XI. 1941)

In the vast accumulation of literature on plant grafting ([1], [2]) we find the subject to have been treated mainly from the morphological and physiological angles, while the formation of chemical substances induced by the operation, as well as their exchange between the stock and the scion have received little attention.

The question of how the chemical composition of the components involved is affected by grafting is discussed in a very few works, and no agreement has been reached in most of the cases ([3–11]). From the data that are available it is difficult to draw a conclusion on the following two points: 1) when chemical substances typical of the stock appear in the scion, they may be supposed to have been synthesized there under the influence of the stock or else simply transferred from the latter; 2) and if the reverse is the case and it is the stock which is found to contain new substances, this time typical of the scion, they again may have got in it either by way of migration or by way of synthesis.

Just which of these possible ways is the true one in either of the two cases? We were concerned with the first case in our experiment, in which *Solanum lycopersicum* (variety Tookwood) was grafted upon *Datura stramonium*. The scions were seedlings in the stage of two leaves. Cleft-grafting was used, and the tissues of the two components grew well and quickly together at the site of union (in a humid chamber). The Jimson weed plants used for stock had well advanced in development at the time of grafting and bore many leaves; the graft was inserted into one of the branches in the crown. The tomatoes made good development on thorn-apple plants. Their leaves would be removed as soon as they appeared, in order that the scion should receive no other substances, besides those manufactured by the stock. Without leaves it had no possibilities for assimilation by itself, and yet it formed a sufficient number of fruits which grew ripe. Under these conditions there was good ground to believe that the fruits had formed at the expense of the stock's plastic substances alone and that with these substances atropine must have been carried along and was now available in the fruits. In literature ([12]) tomatoes grafted upon belladonna had been reported to contain atropine only in their stems.

To detect the presence of atropine in the fruits in our case, we turned to account the biological action of this substance on the human heart. And if

the fruits obtained as a result of grafting were much inferior to those from the ungrafted controls in taste, they could be eaten nevertheless. Two fruits at a time, each measuring 3—4 cm across, would produce an unpleasant effect on the organism though not a very strong one. All symptoms of affection by atropine would appear one and a half hours after the fruit had been taken:

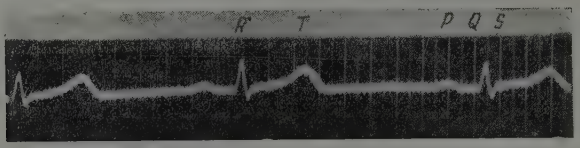

Fig. 1. Electric record of heart function before taking in the tomato fruits: *QRS*, the phase of impulse transmission from the auricle to the ventricles, and peak *R* are constant all along the curve, which is evidence that the heart was working normally.

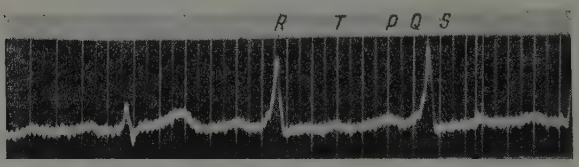

Fig. 2. Electric record of heart function 1.5 hours after taking in the tomato fruits. The interval between the peaks has decreased considerably, and still more pronounced is the reduction of the full pause *R—R*; *QRS* varies along the curve. High *R* peaks alternate with low ones. The normal work of the heart had suffered an unmistakable deviation.

delated pupils, a sense of discomfort due to dryness of the mouth and a slight general excitation. At that time electric cardiographic records were made (Fig. 2). Numerically the recorded results are represented in the annexed table.

Human Heart's Function as Affected by the Fruits of Tomato Scions Grown on Thorn-Apple Stocks

Indices of heart activity	Normal		In response to the fruits (after 1.5 hrs)	
	M	Lim	*M*	Lim
Heart beats per minute	64.0 34	—	103.5	—
Elements of the electrical cardiogram in seconds:				
QRST	0.385	0.35—0.42	0.295	0.27—0.32
ST(β)	0.115	0. 1—0.12	0.08	0.07—0.1
TR	0.39	0.35—0.40	0.06	0.05—0.07
R—R	0.937	0.92—0.96	0.58	0.55—0.6
Systolic index, in %	41.09	—	50.86	—
Pause, in %	41.6	—	11.2	—

One may see from these figures that the pulse registered more beats after 1.5 hours and the time intervals between the peaks on the cardiogram had become shorter, the reduction in the pause of the heart being especially strong (from 41% down to 11% of the heart cycle). At the same time the systo-

lic activity of the heart increased in duration from 41 up to 50%. On the cardiograms (Figs. 1 and 2) peak R had become more prominent, while peak T had decreased in size, which was evidence of reduced contraction of the ventricles and increased irritability of the heart. Another characteristic feature was the alternation of high and low peaks R and the disappearance and reappearance of peaks S on the cardiographic records.

All of this testified in an objective manner to the presence of considerable quantities of atropine in the fruits of tomato variety Tookwood grown upon Jimson weed. As this substance could not have been manufactured by the tomato scions which bore no leaves, we are bound to conclude that it had passed in them from the stock.

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MICROBIOLOGY

FRACTIONAL ELUTION AS A METHOD FOR PURIFICATION OF ADSORBED BACTERIOPHAGE

By A. E. KRISS

(Communicated by A. A. Richter, Member of the Academy, 31. I. 1941)

The problem whether the bacteriophage is a body of protein nature or its lytical ability is not associated with protein, has not been solved so far. Difficulties involved in the method of obtaining bacteriophage from cleared bacterial cultures in broth which contains besides the phage and the constituents of the medium also metabolic products of the bacteria that had multiplied before lysis set in, as well as decomposition products of bacteria, make questionable the effectivity of the methods of phage purification applied in those studies which tend to prove the protein nature of the lytic agent.

On the other hand, investigations which were carried out to prove the existence of protein free phage preparations are far from being reliable, so far as the initial phage activity is concerned; due to the decrease of the number of active phage units in purified preparations, the amount of protein may drop to such an extent that its detection will become limited by the sensitivity of the existing tests for proteins and protein components.

The aim of the present investigation was to work out a method that would permit to purify gradually phage preparations without loss of initial activity during all the consecutive stages of the process.

We thought it feasible to separate the phage from substances not bound intimately with the phage, and consequently not determining its activity, by means of various elution methods, i. e. using for our purpose varying adsorption properties of the components of a «broth» phage culture.

Experiments were carried out with coli and *Salmonella* Danysh (rat typhoid) phages. It proved comparatively easy to obtain on ordinary tenfold diluted meat infusion broth phages reaching a titre of 10^{-8} and in some cases 10^{-9}. In order to adsorb a cleared bacterial culture filtered through a Zeits apparatus we used ascanite—an adsorbent obtained from the Tbilissi Institute for Applied Mineralogy. The choice of the adsorbent played a decisive rôle, and we would emphasize that all the following elution procedures can be applied only to this particular adsorbent, i. e. ascanite.

Before using it for experimental purposes, «raw» ascanite was treated in the following manner; a certain weighed portion of ascanite mixed with a double amount of 20% sulphuric acid was heated for 6 hours in a glass vial on a boiling hot bath, after which the mixture was left overnight at room temperature and then rinsed with distilled water until a total elimination of all SO_4 ions from the filtrate. It was found empirically that the repeti-

tion of this procedure increases the adsorption capacity of ascanite; this is why in our last experiments we used it «activated», i. e. after a secondary treatment with sulphuric acid.

Phage broth «cultures» were absorbed by ascanite columns of varying height and diameter, according to the volume of the material investigated. To purify a liter of broth containing phage it was necessary to use a column of «activated» ascanite 5 cm high and 16 cm wide, its pH being equal to 4.26. The pH value is most important for the success of the experiment, since a drop in acidity lessens the adsorption properties of ascanite.

1 250 cm^3 of the Danysh-phage investigated by us was a yellow clear fluid with a pH equal to 7.31. The lytic activity of 1 cm^3 of phage was:

not diluted	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}
++++	++++	++++	++++	++++	++++	+++	++	t. vierg. 3.

A 250 cm^3 part of the original quantity was burnt after the Kjeldahl method to determine total nitrogen. The nitrogen contents referred to 1000 cm^3 of phage was found to be equal to 114.4 mg. The remaining volume (1000 cm^3) of phage was filtered through the column of the adsorbent. The fluid which has passed through the adsorbent was colourless and clear; its pH = 2.76*. The determination of its lytic activity showed a total absence of phage.

It was presumed at first that the phage activity was reduced by the high acidity, but this presumption proved to be fallacious, because as soon as the pH of the filtrate was raised to 7.0, its lytic ability became nil as before. In order to avoid possible mistakes, nitrogen determination was carried out for the entire volume of the fluid. Nitrogen contents in 1000 cm^3=11 mg. Biuret reaction negative. Thus, it follows that the phage became completely adsorbed, as well as a considerable part of attending nitrogenous admixtures.

Our next step was to remove nitrogenous admixtures by means of elution, preserving the phage in the adsorbed state. The best results were obtained by means of a saturated KH_2PO_4 solution (pH=3.93). The KH_2PO_4 solution was divided into three fractions 500 cm^3 each and filtered consecutively through the column bearing the adsorbed phage.

The 1st fraction contained characteristic white flakes and yielded a strong positive Biuret reaction (pH=3.73). Lytic test** gave negative results; the fluid contained no phage. Total nitrogen=77.35 mg ***. This indicates that even during the first phase of eluation about 2/3 of the initial amount of nitrogenous substances were successfully removed. The 2nd fraction clear, colourless, pH=4.01, contained a total of 10.56 mg *** nitrogen. The 3rd fraction (pH=3.92) showed a decrease in nitrogen content which dropped to 6.4 mg ***.

We regret to mention that owing to technical reasons it was impossible to continue the elution of admixtures from the adsorbed phage to total disappearance of nitrogen in the eluate, which, to our opinion, is most important. The lytic test of eluates proved the absence of phage **. In order to eluate purified bacteriophage, the entire volume of ascanite containing the adsorbed phage was placed into a vial containing a sodium bicarbonate solution (300 cm^3 of saturated $NaHCO_3$ solution + 700 cm^3 distilled water) whereupon the mixture was shaken for 15 minutes. Thereafter the formed suspension was poured into a funnel, the fluid was removed and 1000 cm^3 of distilled water were filtered through the column formed owing to sedimentation.

* Considerable pH drop in the filtrate as compared with the broth pH and that of ascanite is a very characteristic feature.

** Including neutralization of eluates.

*** The entire volume of eluate was burnt.

The total volume of phage eluate (pH higher than 8.0) was 2000 cm³. The lytic activity of 1 cm³ of the fluid was:

not diluted	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}
++++	++++	++++	++++	++++	++++	++	++	t. vierg. 1.

Nitrogen contents in the entire eluate volume * = 4.72 mg.

Comparing the titre of the purified phage with the initial one, it can be seen that it has undergone no changes, notwithstanding the decrease in nitrogen from 114.4 to 4.72 mg.

In order to check up the nitrogen content in the reagents and the adsorbent, another experiment characterized by similar quantitative interrelations was carried out, whereby but distilled water instead of phage was filtered through the column. Total nitrogen index in the 1st fraction of KH_2PO_4—1.4 mg, in the 2nd—0.6 mg, and in the 3rd—0.2 mg, while in the $NaHCO_3$ solution—6.5 mg.

It seems that a direct comparison of the experimental data with the control ones is sufficient to show an almost total absence of nitrogen from purified phage; however, taking into account the well known errors of the Kjeldahl method, we do not feel entitled so far to draw such conclusions.

The method of fractional elution which, unlike to other methods, makes it possible to maintain the initial phage activity throughout purification processes, requires further investigation and improvement. However, it seems to be a promising method, both for the investigation of the nature of bacteriophage and for therapeutical practice which requires purified phages.

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* The entire volume of eluate was burnt.

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MICROBIOLOGY

MUTABILITY OF NODULE BACTERIA

By N. A. KRASSILNIKOV

(Communicated by A. A. Richter, Member of the Academy, 31. I. 1941)

Transformation of non-virulent forms of bacteria into virulent forms, non-pathogenic into pathogenic, when the two kinds are living together, has been observed by but a few authors ([1–4]). To their observations we are able now to add some new data bearing on nodule bacteria.

Bacterial filtrate of a *Rh. trifolii* culture, strain No. 19 (Caucasian), obtained by filtration through Börkefeld's filter was inoculated by some other species of nodule bacteria as well as by non-virulent lines obtained experimentally from the same strain No. 19. In the filtrate those bacteria were kept for a period from 1 to 7 months at 17—18° C, being tested every 1—1.5 months for their ability to form nodules on clover roots. For that purpose sterile seeds of clover were grown under sterile conditions in flasks on agar and inoculated with the bacteria in the filtrate. For control was used the clover inoculated with the filtrate only, there was also one inoculated with nodule bacteria not treated with the filtrate, and one more inoculated with initial strain (No. 19) of *Rh. trifolii*.

The cultures kept in the bacterial filtrate were:

Nodule bacteria of:		Non-virulent strains of:
1) peas	— 2 strains	7) clover 19 A_3 smooth
2) vetch	— 2 »	8) clover 19 A_1 rough
3) alfalfa	— 2 »	9) clover 19 C
4) soya	— 1 strain	10) clover 19 D_1
5) phaseolus	— 1 »	11) clover No. 1
6) clover No. 19	— 1 »	

In selecting the cultures they were all carefully tested for non-virulence with respect to clover. It was proved by numerous experiments run in flasks on agar, in sand and in soil under sterile conditions that none of them was able to call forth formation of nodules on clover roots. But it must be pointed out here that so far as the nodule bacteria of peas, vetch, soya, alfalfa and phaseolus are concerned, their non-virulence was restricted to their relation to clover. For their respective host plants they were all virulent.

Thus checked, the cultures of nodule bacteria were seeded on filtrates and observed for growth and poisoning behaviour. The bacterial filtrates had been obtained from 10, 20 and 50-day-old clover cultures. In each case they were inoculated with a single strain of bacteria. The results of the tests are brought together in the table.

It may be seen from it that after a long stay in the filtrate of *Rh. trifolii* the nodule bacteria of vetch, peas, alfalfa and phaseolus acquire the properties to infect clover and to form nodules on its roots. Various lengths of time are required for them to become so endowed. This depends upon the spe-

Virulence of Nodule Bacteria Kept in the Filtrate from a 60-day-old Culture of *Rh. trifolii**

Culture	Untreated control	Length of treatment			
		1 month	2.5 months	5 months	7 months
				number of nodules in 10 plants	
Filtrate without bacteria, control	—	—	—	0	0
Nodule bacteria of peas. str. 1	—	—	+	15	13
peas, str. 5	—	+	+	28	25
vetch, str. 10	—	—	+	56	100
vetch, str. 14	—	—	—	36	75
alfalfa, str. 8	—	—	+	8	6
alfalfa, str. 12	—	+	+	18	12
phaseolus	—	—	+	25	53
soya	—	—	—	0	0
Clover, str. 19	+	+	+	38	45
line A_3 rough	—	—	—	0	0
line A_3 smooth	—	—	—	17	28
line A_1	—	—	—	0	0
line C	—	—	—	0	0
line D_1	—	—	—	28	43
line No. 1	—	—	—	5	3

* In the first three columns the presence or absence of nodules is indicated by the sign + or —, respectively. In the two other columns the number of nodules per 10 plants is given.

cies, and even within a single species all its non-virulent strains are not transformed into virulent ones at the same rate. While the strains of alfalfa No. 12 and pea No. 5 could form nodules on clover roots after one month in the filtrate, the experimental strains A_3, D_1 and No. 1, obtained from strain No. 19, could do this only after 5 months. And the nodule bacteria of soya as well as the experimental strains A_1, A_3 and C had undergone no transformation at all; 5 months in the same filtrate had failed to make them virulent.

In all of the tests referred to in the table, the filtrate was one obtained from old, 2-month cultures of *Rh. trifolii*, strain No. 19. With younger cultures there was either no influence whatsoever on the virulent qualities of the bacteria, or else the effect was a great deal weaker. None of these strains was affected by a filtrate from a 10-day culture of *Rh. trifolii*, and when using a filtrate from a 20-day culture only the strains No. 5 pea, No. 12 alfalfa and that of phaseoleus became virulent for clover in a space of 5 months.

Treatment with bacterial filtrates is apt to transform the nodule bacteria in several other ways, besides changing their behaviour as poisons. This is reflected very conspicuously in the fermentation of sugars. Strains, otherwise unable to ferment the lactose or maltose, do this after being kept in the filtrates, and conversely. No one of these changes, however, is connected with the change in the poisoning behaviour and each of them takes place independently of the others.

The cultural and morphological characters of nodule bacteria are not affected by the treatment to any significant extent.

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MICROBIOLOGY

ON THE QUESTION OF THE VIRUS OF SPONTANEOUS ENCEPHALITIS OF MICE

By V. D. SOLOVIEV and A. K. SHUBLADZE

(Communicated by N. F. Gamaleja, Honorary Member of the Academy, 30. XI. 1940)

1. Among mice diseases caused by neurotropic ultraviruses affecting mostly the central nervous system, two have been described: lymphocyte choriomeningitis and spontaneous encephalitis. The virus of lymphocyte choriomeningitis was isolated for the first time by Armstrong and Lillie in 1934, while inoculating monkeys with material obtained from patients during the St. Louis epidemic of encephalitis in America. Thereafter Traub (1935) studied a virus strain similar to that found by Armstrong and Lillie, though originating from mice suffering from spontaneous infection. Later on Lepin and Sautter isolated the choriomeningitis virus from mice in Paris, while Laigret and Durand succeeded in finding the same in Tunis. M. Theilor described in 1933 a new virus infection of American mice—spontaneous encephalomyelitis. Sick mice showing signs of a slight paralysis of the hind extremities were found among a new batch of healthy animals in the vivarium of the Rockefeller Institute.

Injection of brain suspension of sick mice into the brain of healthy mice caused similar paralysis in healthy animals. Thus, a total of 5 identical virus strains were isolated from 7 sick mice.

Since mice are susceptible only to intracerebral and intrarhynal inoculation of the encephalomyelitis virus, this is the only method for obtaining passages. The virus has never been found in the blood of infected mice. Infected mice which have survived may harbour the virus in the brain and mainly in the spinal cord during 1 year following inoculation. Monkeys proved immune to encephalomyelitis virus of mice. The pathogenicity of the virus for mice is comparatively low, reaching after a series of passages a dilution grade of 10^{-4}.

Following Theilor's discovery there appeared a series of communications referring the existence of spontaneous virus encephalitis of mice in other countries. The recent investigation by Kawamura, Kasahara and others (1940) bearing on the same question seems to be of special value. These Japanese scientists succeeded in isolating from spontaneously infected mice showing signs of paralysis 4 strains of a neurotropic filtrable virus; further investigation of its immunological properties showed a close relation existing between the virus isolated from mice and the agent of the Japanese (summer) encephalitis.

Only white mice are susceptible to the virus of spontaneous encephalitis of mice, whereas the virus of choriomeningitis is pathogenic for monkeys, guinea-pigs and white rats, too. There exist data concerning the susceptibility of man to the virus of lymphocyte choriomeningitis of mice.

In the end of January 1940, we found among a new batch of white mice kept for the needs of the Virus Laboratory of the Central Institute for Epidemiology and Microbiology 2 animals with semiparalyzed posterior and anterior extremities. Among 8000 mice which have passed recently through the laboratory only 5 paralyzed animals were found. The sick mice were killed and the brain of each was used to prepare a 10% emulsion in peptone meat infusion broth. Thereafter these emulsions were injected into the brain of healthy mice. Applying successive passages, it became possible to isolate and investigate one strain of the virus of spontaneous encephalitis of mice.

Among 11 mice inoculated with the brain emulsion of paralyzed mouse № 1, one mouse perished with no external manifestations of the disease, while the other showed signs of paresis of the posterior extremities on the 12th day after inoculation. The animal was killed and its brain used for passages on a new batch of healthy mice. During the second passage all the mice inoculated became infected and the virus isolated from them was passed successfully from one animal to another by means of intracerebral injections. At present our laboratory possesses the 10th and the 11th generations of this strain.

While investigating the pathogenicity of this strain for various animals it became evident that rabbits, guinea-pigs, white rats and birds (*Acanthis flanemla*) are insusceptible. Different results were obtained when inoculating into the brain domestic mice (*Mus musculus*). Out of 6 domestic mice 4 fell ill after a 6—10-day incubation period and displayed the same symptoms of lesion of the central nervous system which are typical of infected white mice, i. e. paresis of hind paws and succeeding death.

The isolated virus of spontaneous encephalitis of mice is easily filtered through Berkenfeld V, Chamberland L_3 and Seitz filters. It is preserved in 50% glycerine during 60 days at 4—6° C. Heating a 10% brain emulsion of infected mice on a hot bath at 60° C for 30 min. kills the virus.

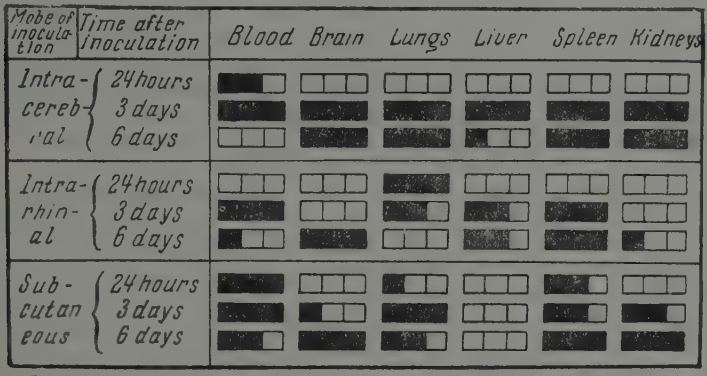
White mice are highly susceptible to the passage virus of spontaneous encephalitis, whose virulence intensified by the passages now reaches a dilution grade of 10^{-6}. Irrespective of the mode of introduction of the virus, an acute fatal infection affecting the central nervous system and followed by pareses and paralyses develops in most cases. The intrarhynal mode of inoculation is the least effective one, and shows the longest incubation period, as well as a somewhat lower percentage of positive results.

The clinical course of the disease in mice infected with the virus of spontaneous encephalitis is similar to that of the disease caused in mice by inoculation with viruses of tick, Japanese and American encephalitis. After incubation lasting 4—8 days and but seldom more, the posterior and less often the anterior extremities become paretic; as a rule, the animals perish within 1—3 days. The manifestations of the disease are alike both in experimentally and spontaneously infected animals. Cramps and convulsions are observed but seldom.

Histopathological investigations carried out under the supervision of Prof. M. S. Margulis revealed the presence of meningo-encephalitis combined with neurophagy particularly manifest in the cells of the anterior horns of the spinal cord.

2. The clinical picture of the disease in mice and the pathohistological changes in the brain of sick animals permit the agent of the disease to be referred to the group of neurotropic ultraviruses. In order to determine the

affinity of the virus for other organs and tissues, as well as the way of its spreading in the body of mice, we studied the distribution of the virus in the organism of the mouse under various modes of inoculation. During our experiments 3 groups of mice, each represented by 20 animals, were inoculated with a fatal virus dose introduced into the brain, in the nose or subcutaneously. 2 mice at a time were selected from each group every 24 hours, 3 and 6 days. These were killed and the brain, lungs, liver, spleen, kidneys and blood extracted. The corresponding organs were mixed, thoroughly rinced with saline and, after being a long time ground with sand, emulgated in broth. The emulsion prepared with the organs, as well as the blood, were



injected into the brain of healthy mice. From the figure it can be seen that 24 hours later the brain does not show any of the virus, even when the latter had been injected immediately into the region of the central nervous system. The longest time is required for the virus to reach the brain when it is introduced intrarhynally. 24 hours after the intrarhynal inoculation the virus can be found only in the lungs, whereas no traces of it are detected in the brain even after 3 days; on the 6th day after inoculation the presence of the virus can be detected in all the organs except the lungs, wherefrom it disappears by the end of the period mentioned. The absence of the virus from the brain during the first 3 days succeeding intrarhynal inoculation disproves the possibility that the virus may reach the bulbus olfactorius and other regions of the brain directly through the terminations of nervus olfactorius. Evidently, as a result of nasal inoculation, the virus is spread indirectly, through the general circulatory system.

When introduced into the brain, the virus can be detected 24 hours later in blood only. By the 3rd as well as by the 6th day the virus is present in all the organs. By the end of this period the blood contains no virus. 24 hours after subcutaneous inoculation the virus can be found in the blood, lungs and spleen; 3 days later it is present in all the organs except in the liver. On the 6th day the virus is present in the blood, brain, lungs, spleen and kidneys.

From the character of distribution and spreading of the virus in the organism of mice one can conclude that it is considerably, though not absolutely neurotropic, and that it shows a tendency to spread through the circulatory system.

3. The immunity of guinea-pigs and white rats to the virus obtained by us is a sufficiently typical trait to distinguish it from that of lymphocyte choriomeningitis. Our virus is alike the strain of the Theilor virus of sponta-

neous encephalitis of mice. They differ in the following details: our virus is more pathogenetic for white mice, reaching a dilution grade of 10^{-6}, and possesses the faculty of causing infection irrespective of the mode of inoculation. Moreover, the American virus has never been found in the blood, when the latter was tested for infectiveness on the 1st, 3rd, 6th and 8th days after inoculation, whereas our virus was always present in the blood with any mode of inoculation.

We attached great importance to the relation existing between our virus and the viruses of the tick and Japanese encephalitis. As mentioned above, all these viruses cause the same clinical picture of infection in white mice.

Neutralisation experiments have shown that specific immune serum against tick encephalitis neutralises our virus but to a slight extent. Experiments have also been conducted involving reciprocal immunity tests in actively immunised mice. It became clear that mice immunised with the formalinised vaccine of the virus of tick encephalitis became resistant to subcutaneous inoculation of homologous virus diluted by 10^{-3}—10^{-4}, whereas subcutaneous introduction of the virus of spontaneous encephalitis diluted likewise calls forth a fatal infection both in immunised mice and control animals. Additional reciprocal neutralisation tests confirmed in general the data cited above, which shows that the viruses of human tick encephalitis and our strain of spontaneous encephalitis of mice are not identical.

The epizootology of the spontaneous encephalitis of mice has so far been studied insufficiently. According to Theilor, the frequency of spontaneously infected mice is not above 1 to 2000. Mice suffering from paralyses are usually young ones, aged 6—7 weeks. Experiments with inoculation by contact, contrary to the data concerning lymphocyte choriomeningitis, gave negative results. Theilor suggests that the virus is transmitted by blood sucking insects parasitic on mice.

In our experiments we placed more than once healthy mice in cages together with infected animals and obtained no data pointing to the possibility of contact inoculation.

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PHYSIOLOGIE

EINE SCHNEIDEMÜHLE FÜR SCHWER ZERKLEINBARE ELASTISCHE GEWEBE NACH EINEM NEUEN PRINZIP

Von W. E. SOKOLOWA

(Vorgelegt von A. A. Richter, Mitglied der Akademie, den 27. I. 1941)

Bei biochemischen und chemisch-analytischen Untersuchungen lebender Gewebe ist deren feinste Zerkleinerung häufig ein ausserordentlich schwieriges Verfahren. Sämtliche Versuche zur Zerkleinerung von beispielsweise Knorpel mit den verschiedensten modernen Mahlvorrichtungen haben sich als völlige Misserfolge erwiesen. Bei den üblichen Schneidemühlen «entschlüpft» der glatte Knorpel dem Messer, beim Durchpressen durch enge Öffnungen komprimiert er sich, um sich dann wieder auf sein früheres Volumen auszudehnen.

Nach entsprechenden Voruntersuchungen ist es uns gelungen, ein höchst einfaches und bequem zuhandhabendes Modell zu konstruieren, durch das rasche und feine Zerkleinerung elastischer und weicher Gewebe auf rationelle Weise zu erzielen ist.

Es handelt sich um eine Schneidemühle (Abb. 1), die aus zwei Details besteht: einer Schraube und einem Kölbchen mit einem Gewinde. Die Schraube wird in den Kolben eingeschraubt; ihr sechseckig zugespitztes Ende legt sich beim Einschrauben mit seiner ganzen Fläche fast an den konischen Boden des Kölbchens an. Die Gänge der Schraube und des Kölbchens werden von vier bis acht graden Rillen durchschnitten, die, gleichmässig voneinander entfernt, parallel zur Schraubenachse an der Innenfläche der Peripherie gelegen sind. Die Rillen auf der Schraube stellen im Schnitt ein rechtwinkliges Dreieck dar, das mit der Hypothenuse nach seiten der Schraubendrehung beim Einschrauben gerichtet ist; die eine Kathete hat radiale Richtung; die Tiefe der Rillen beträgt $^3/_4$ der Gangtiefe und ist gleich der Gesamtlänge einer Rille. Die Rillen auf der Innenfläche des Kölbchens sind im Schnitt ebenfalls von der Form eines rechtwinkligen Dreiecks, aber die radial gerichtete Kathete liegt auf der anderen Seite des Dreiecks, so dass die Rillen von Kolben und die Schraube beim Eindrehen der letzteren sich zuerst mit den Hypothenusen treffen. Die Tiefe der Rillen ist längs der Kolbenhöhe nicht gleich: am Boden entsprechen sie der Gesamttiefe des Gewindes, werden aber nach dem oberen Rande zu flacher und berühren die beiden obersten Gänge überhaupt nicht mehr (Abb. 1). Bei dieser Schnittanordnung entstehen mit jeder Schraubendrehung tetraederförmige Ausschnitte, die auf der Schraube von gleicher Grösse sind, während sie sich auf dem Kolben verkleinern, je näher sie dem oberen Rand kommen. Wenn die Schraube eingedreht wird und die Rillen auf der Schraube

sich genau gegenüber den jenen auf der Kolbeninnenfläche befinden, so bilden sie zusammen einen durchgängigen Kanal längs des ganzen Gewindes, eben aus diesen Tetraedern bestehend. Bei der geringsten Schraubendrehung zerfällt dieser Kanal in einzelne Tetraeder, die nicht mehr aufeinander passen.

Durch die radial gerichteten Flächen der Rillen von Schraube und Kolben kommt die Schneidewirkung zustande.

Wird die Schraube in den mit dem zum Zermahlen bestimmten Material gefüllten Kolben eingedreht, so wird dieses durch den Druck der sich bewegenden Schraube zwangsweise in die Kanäle getrieben, und die kreisende Bewegung bewirkt die Zermahlung des in den Kanälen zusammengepressten Gewebes in kleine Stückchen, die immer kleiner und kleiner werden, je nach dem Aufrücken zum oberen Rande und der Verengerung der Kolbenrillen. Bevor das zermahlene Gewebe nach aussen gelangt, wird es durch einen engen Spalt zwischen Schrauben- und Kolbengang gepresst, d. h. auf den beiden obersten Gängen wird es von den Rillen nicht mehr durchschnitten. Die Schraube ist zur bequemeren Handhabung mit einem kleinen Quergriff (Winde) versehen; der Kolben steht auf einem Untersatz und ist mit einem Tellerchen ausgestattet, auf den das aus dem Schneidegetriebe herausquellende zermahlene Material fällt, das, je nach gewünschtem Grad der Zerkleinerung, in feinste Partikeln zermahlen werden kann. Das Volumen des Kölbchens kann für beliebige Gewichtsmengen eingerichtet werden, von mikroskopisch kleinen Quantitäten bis zu mehreren Grammen und sogar Dekagrammen. In unserem Laboratorium wird am häufigsten ein «Halbgramm»-Modell verwendet, eine Mühle mit 4 Kanälen, die je 4 Rillen auf Schraube und Kolben besitzt. Durchmesser der Schraube—6 mm, Höhe des Kölbchens—25 mm, Schraubengang—Schnittiefe—1 mm. Ferner haben wir ein praktisches Modell mit einem Schraubendurchmesser von 15 mm und Kolbenhöhe von 35 mm (Volumen 6.1 cm^3), mit demselben Mass des Schraubengangs und der Schnittiefe und je 8 Rillen auf Schraube und Kolben.

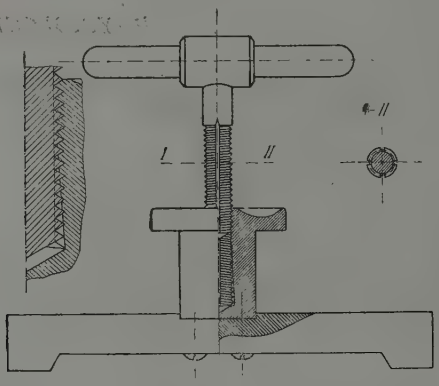

Abb. 1.

Zwecks Erzielung des optimalen Reibungskoeffizienten soll für Schraube und Kolben verschiedenartiges Metall verwendet werden, z. B. Stahl und hartes Messing; letzteres taugt jedoch nur zur Zerkleinerung weicher Gewebe, und dies auch nur in jenen Fällen, wo die Kupferionen nicht störend auf die Analyse einwirken. Darum bevorzogen wir nichtrostenden Chrom-Nickel-Stahl für den Kolben und Silber für die Schraube (die Apparate werden in der Werkstatt eines der Moskauer chemischen Institute hergestellt).

Um festzustellen, ob das gewählte Material keine inaktivierende Wirkung auf das zu untersuchende Ferment ausübt (in unserem Falle auf das Katepsin), nahmen wir vergleichende Bestimmung der Aktivität des Katepsins mit Zusatz von abgeschabtem Stahl und ohne solchen Zusatz vor. Die Aktivität des Katepsins wurde bestimmt nach der Verdauung von Gelatine durch ein Glyzerinextrakt aus den Hinterextremitäten von Axolotln, wobei

der Zuwachs an Carboxylgruppen nach der Methode Willstätter-Waldschmidt-Leitz bestimmt wurde. Dabei erhielten wir folgende Befunde:

Versuchsbedingungen . . .	Aktivität des Katepsins in cm^3 0.05 N KOH auf 1 cm^3 Versuchsmaterial
Ohne Zusatz von Stahl . .	$\left.\begin{matrix}0.62\\0.55\end{matrix}\right\}$ 0.59
Mit » » » . .	0.59

Die Ergebnisse zeigten, dass durch das Metall keinerlei Inaktivierung des Katepsins verursacht wird.

Die Anzahl der Schnitte, die durch eine Mühle von diesem Typus erzielt wird, lässt sich leicht nach der Formel $x=2\,n^2\,z$ berechnen, wobei x—Anzahl der Schnitte bei einer vollen Schraubenumdrehung um 360°, n—Anzahl der Rillen auf der Schraube (die der Rillenzahl auf dem Kolben gleich ist), z—Anzahl der Schraubengänge.

Wenn man die Zahl der Umdrehungen vom ersten Erscheinen der zerkleinerten Masse auf dem Teller bis zum völligen Durchmahlen als mittleren Wert für z annimmt und den für den vorliegenden Fall berechneten Wert von x mit der Zahl der Arbeitsumdrehungen multipliziert, so kann man (annähernd) auch die Gesamtzahl von Schnitten berechnen, die die Mühle aus der genommenen Gewichtsmenge erzeugt hat.

Beim Eindrehen von 10 Schraubengängen ergibt das erste Modell $2\times4^2\times\times10=320$ Schnitte auf eine Schraubenumdrehung (46000 Schnitte bei $^1/_3$ Gramm eingefülltem Material). Das zweite Modell ergibt, bei durchschnittlichem Einschrauben um 20 Gänge, $2\times8^2\times20=2560$ Schnitte auf eine Umdrehung (etwa 75000 Schnitte bei einer Gewichtsmenge von 3 Gramm).

Das Durchmahlen selbst nimmt ein bis zwei Minuten in Anspruch. Das Gewebe wird am besten mit einem Glasstäbchen eingefüllt, von Form der Stäbchen, die man zum Zigarettenstopfen benutzt, dessen Durchmesser ein wenig kleiner ist als der innere Durchmesser des Kölbchens.

Die beschriebene Mühle hat sich in unserem Laboratorium zur Zerkleinerung von Axolotlknorpel als sehr brauchbar erwiesen. Mit ihrer Hilfe gelingt es nicht nur, die für diese Manipulation erforderliche Zeit bedeutend zu verkürzen (ungefähr auf den 25 Teil), sondern auch einen solchen Grad der Zerkleinerung zu erzielen, wie es bisher ganz unerreichbar war. Dabei ist der Verlust an Material nicht grösser als bei den sonst üblichen Methoden (Schere und Mörser).

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HISTOLOGIE

DAS WACHSTUM UND DIE VERWANDLUNGEN DES EPITHELS DER GALLENBLASE AUSSERHALB DES ORGANISMUS

Von N. I. GRIGORIEV

(Vorgelegt von I. I. Schmalhausen, Mitglied der Akademie, den 28. XI. 1940)

Im Schrifttum sind verhältnismässig wenige Arbeiten über die Züchtung der Epithelien des Darmtypus in vitro vorhanden ([1], [2] und einige andere). In bezug auf die Züchtung des Epithels der Gallenblase gibt es nur einzelne Arbeiten ([3], [4]), in welchen die Bildung der Epithelmembranen der Wachstumszone beschrieben wird. Die meisten Verfasser halten die Auskleidung der Gallenblase für typisches einschichtiges einreihiges Epithel. Einzelne Autoren schrieben ihm aber den Bau eines eigenartigen mehrreihigen Epithels zu ([5]). Als Material für die vorliegende Untersuchung dienten die Gallenblasen folgender Tiere: der Embryone des Hausschweines (von 6 bis 25 cm lang), der Kaninchenembryone und junger Kaninchen, der Hühnerembryone und Kücken, der Natter, der Eidechse, des Grassfrosches, des Axolotls, des gestreiften Tritons, einiger Knochenfische (Schmerle, Karausche, Plötze). Die Blasenteilchen wurden nach dem Verfahren des hängenden Tropfens explantiert. Das Kontroll- und Versuchsmaterial wurde im Laufe bis 1—1.5 Monaten auf gewöhnliche Weise behandelt.

Der Bau des Epithels der normalen Gallenblase erwies sich bei allen untersuchten Tieren im allgemeinen als äusserst ähnlich. Das ist typisches einschichtiges einreihiges Epithel vom Darmtypus mit hochprismatischen Zellen. Die Grösse der Zellen variiert bei verschiedenen Vertretern der Wirbeltiere (sehr kleine Zellen beim Huhn und besonders grosse bei den Urodelen). Kerne ovaler Form liegen im Basalteil der Zellen. Im Apikalteil der Zellen befindet sich mucoides Sekret, dessen Anordnungsweise bei verschiedenen Tieren nicht vollkommen gleich ist. Bei sämtlichen Tieren hat das Epithel der Gallenblase einen Cuticularsaum, welcher in verschiedenem Grade ausgesprochen ist, und gut sichtbare Verschlusstreifen. Basalzellen fehlen. Bei verschiedenen Tieren sind in ungleicher Menge einzelne Lymphozyten vorhanden, welche auf verschiedenen Höhen der Epithelschicht ungleichmässig angeordnet sind. Die Basalmembran ist schwach ausgebildet.

Das Epithel der Gallenblase wächst in den Kulturen extensiv, wobei es Membranen bildet, und die Oberfläche des Explantats epithelisiert. Abgesehen vom Epithelwachstum, wurde in einem Teil der Kulturen auch das Wachstum der Mesenchymderivate und des Mesothels beobachtet. Das Wachstum des Epithels wurde durch die Verflüssigung der Fibringerinnsels begleitet. Nur bei den Fischen gelang es mir keine extensive Wachstumszone des Gallenblasenepithels zu erhalten. Bei sämtlichen Tieren bestand die Epi-

thelwachstumszone aus einer Schicht von polygonalen Zellen, die meistens abgeplattet, seltener von niedriger prismatischer Form waren. Besonders hoch waren die Epithelzellen im Falle einer gemischten Wachstumszone, wenn die Epithelelemente sich an der bindegewebigen Wachstumszone fortbewegten. Bei den Säugetieren und Amphibien konnten vereinzelte Zellen in einigen Bezirken der Wachstumszone ein wenig auseinandergehen, wobei sie mittels zytoplasmatischer Fortsätze von verschiedener Grösse verbunden blieben. Derartige aufgelockerte Bezirke blieben in den Kulturen aus der Gallenblase der Kücken und Reptilien beinahe gänzlich aus. Das Protoplasma der Zellen der Epithelmembranen enthielt Fettvakuolen (besonders zahlreich waren sie bei den Kücken) und zuweilen kleine Inklusionen von mucoidem Sekret. Der Bau der Kerne war bei verschiedenen Tieren ein wenig verschieden. Bei den Säugetieren und besonders bei den Amphibien waren die Kerne reich an Chromatin, das in der Gestalt von Schollen von verschiedener Grösse im ganzen Kern verstreut war. Bei den Vögeln, Reptilien und Fischen waren die Kerne relativ arm an Chromatin, welches fein zerstäubt war und die deutlich hervortretenden Kernkörperchen, in der Zahl von 2 oder 1, gar nicht verdeckte. Karyokinesen wurden in der Wachstumszone bei allen Tieren beobachtet (besonders häufig bei den Vögeln, Eidechsen, besonders selten bei den Amphibien). Bei den Kücken und Reptilien färben sich die Zellgrenzen in den Membranen intensiv mit Hämatoxylin in ihrem ganzen Verlauf. Bei den Säugetieren und Amphibien ist der Zellbau der Membran ebenfalls deutlich ausgesprochen, die Zellgrenzen färben sich aber mit Hämatoxylin nicht in der ganzen Ausdehnung der Membran, sondern nur an einigen Stellen (neben dem Zentralstückchen und besonders zwischen den Epithelzellen, welche sich an der bindegewebigen Wachstumszone ausbreiten). Die Zellgrenzen färben sich nur an der apikalen Oberfläche der Membranen, was die polare Differenzierung dieser letzten betont. Die epitheliale Wachstumszone, welche sich nach dem Herausschneiden aufs neue gebildet hat, hat denselben Charakter, wie vor dem Herausschneiden. Die Epithelmembranen haben bei verschiedenen Tieren manches gemeinsam, sie unterscheiden sich aber so stark in den Einzelheiten (z. B. nach der Form und Grösse ihrer Elemente, der Zellenanordnung, nach dem Entwicklungsgrad der Zellgrenzen, u. drgl.), dass man nach diesen Merkmalen in sehr vielen Fällen bestimmen kann, welchem Tiere diese oder jene Wachstumszone zugehört. Andererseits gelingt es in den Membranen aus dem Epithel der Gallenblase kein einziges Merkmal nachzuweisen, welches sich bei den Vertretern verschiedener Klassen der Wirbeltiere allmählich verändert hätte.

Bei der Züchtung von Teilen der Gallenblase wurde bei allen untersuchten Tieren die Erscheinung der vollständigen oder partiellen Epithelisation beobachtet. Die epithelisierenden Schichten und das im Resultat der Epithelisation entstandene Deckepithel hatten einen einschichtigen einreihigen Bau. Die Basalzellen blieben allerorten aus.

Sehr bald (1—2 Tage nach der Explantation) tritt bei den Vögeln und Säugetieren die vollständige Epithelisation ein. Viel langsamer geht der Epithelisationsprozess bei den Amphibien und Reptilien vor sich; bei ihnen tritt die vollständige Epithelisation meistens am 4.—5. Tage nach der Explantation ein, in einzelnen Kulturen wurde aber sogar am 15.—20. Tage noch keine vollständige Epithelisation beobachtet. Die Form der Zellen der Epithelschicht ist nicht gleich. In einer grösseren oder geringeren Entfernung vom freien Rande der Epithelschicht, mit welcher das Epithel über das freigelegte Bindegewebe rückt, wird eine allmähliche starke Abplattung der Zellen beobachtet. Nach der Beendigung des Prozesses der Epithelisation bildet sich allmählich wieder hochprismatisches Deckepithel. Der Bau dieses

Epithels ist dem Bau des normalen Gallenblasenepithels ähnlich oder sogar identisch. Der Basalteil der Zelle ist vom Kern eingenommen, im Apikalteil bildet sich wieder mucoides Sekret und bleibt bis auf die spätesten untersuchten Züchtungsstadien erhalten. In den hohen Zellen der Epitheldecke sind eine Cuticula, Verschlussleisten und gut ausgesprochene Zellgrenzen vorhanden. In den platten Zellen fehlen das Sekret, die Cuticula, die Verschlussleisten vollständig oder beinahe vollständig, die Zellgrenzen sind aber schlecht sichtbar. Die Kerne der hohen Zellen weisen einen ebensolchen Bau auf, wie die Kerne der Epithelzellen der normalen Gallenblase. Die Kerne der platten Zellen sind in der Regel mit ihrer langen Achse der Oberfläche der epithelisierenden Schicht parallel orientiert, die Zwischenräume zwischen den Kernen sind in diesem Teil der epithelisierenden Schicht nicht immer gleich. Karyokinesen kommen in den hohen, niedrigen und platten Zellen der Epithelschicht vor. Die Anordnung der Karyokinesefiguren ist in den hochprismatischen sich teilenden Zellen analog ihrer Anordnung im Epithel der normalen Gallenblase—die Teilungsfiguren sind in den Apikalteil der Epithelschicht stark verlagert und ihre Achse liegt parallel zur Oberfläche des Explantats. Lymphozyten kommen im Deckepithel nur ausnahmsweise vor. Ein Teil der Mesenchymelemente fällt in den Zentralbezirken des explantierten Stückchens der Degeneration anheim und ihre Menge nimmt mit dem Alter der Kulturen beträchtlich ab.

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EXPERIMENTELLE MORPHOLOGIE

ÜBER DIE MORPHOGENETISCHE WIRKUNG DER KANZEROGENEN KOHLENWASSERSTOFFE BEI AXOLOTLN

Von D. M. FEDOTOV

(Vorgelegt von A. A. Richter, Mitglied der Akademie, 27. I. 1941)

Meine ersten Versuche zeigten, dass die kanzerogenen Kohlenwasserstoffe an Axolotln solche Wucherungen des Hautepithels hervorrufen, welche denen, die die Organisatoren-Invaginatoren, nach N. V. Nasonov, erzeugen, ähnlich sind (1).

In den Versuchen* dieser Arbeit wurde hauptsächlich 1 : 2 : 5 : 6-Dibenzanthrazen, seltener 9 : 10-Dimethyl-1 : 2-Benzanthrazen angewandt, welche wir dank der Liebenswürdigkeit von Prof. L. M. Schabad und Prof. M. I. Uschakov erhielten. Der Kohlenwasserstoff, in einer Menge von 5—10 mg, wurde in 2 ml Azeton gelöst, danach wurde frisches Eiweiss von Hühnereiern hinzugefügt; das Eiweiss gerann und das Azeton wurde abgedampft. Genügend feste Eiweisstückchen, welche nach der Durchtränkung mit Dibenzanthrazen grün wurden, wurden nach der Methode von Nasonov unter die Haut der vorderen und hinteren Extremitäten der Axolotln in Taschen implantiert. Letztere wurden proximal und distal von dem Hautschnitt in der Mitte des Oberarms und des Unterschenkels angebracht. Es wurde eine Serie von Versuchen an Axolotln im Alter von 9 Monaten bis 2 Jahren, mit einer Dauer von 5 Stunden bis 14 Monate angestellt. Das Material des grössten Teils der Versuche, ausser dem der langwierigsten, ist vorläufig studiert und die Resultate werden in dieser Arbeit dargelegt.

Die Wirkung des Dibenzanthrazens äussert sich bei Axolotln sehr schnell. Schon in den ersten Tagen nach der Operation und der Implantation mit Dibenzanthrazen getränktem Eiweiss erscheint in der Haut der Extremitäten Rötung, und die über dem implantierten Eiweiss gelegene Epidermis beginnt grau zu werden. Die Entzündung geht schnell und schroff vor sich. Es bildet sich eine Anschwellung, welche im Verlauf von zwei, drei und mehr Wochen sich in ihrem Ausmass nach vergrössert, die Haut nimmt eine weiss-graue Farbe an, ist angeschwollen, die Blutgefässe unter der Epidermis erweitern sich stark. Die Wundränder heben sich nicht selten empor, und unter ihnen, sowie auch durch die sich über den Implantaten gebildeten Wunden, dringen entfärbte Eiweisstückchen, Eiter und manchmal auch Blut hervor. Die grossen Anschwellungen, entsprechend der Zahl der Taschen mit Einlagen, entstehen so auf den Extremitäten der Axolotln. Nach dem Verlauf von etwa vier bis sechs Wochen geht die Entzündung zurück.

*An der Arbeit nahmen A. B. Silaew und L. B. Koschelewa Teil.

Sie nimmt allmählich eine normale Färbung an, die Anschwellung verschwindet schliesslich, aber der Eiter mit dem Eiweiss dringt noch lange durch die Wunden in der Haut hervor. Die Erhebungen der Haut und die Narbe als rhombenförmige Vertiefung, welche durch die gehobenen Ränder der früheren Wunde begrenzt sind, bleiben gewöhnlich erhalten und verschwinden meistens überhaupt nicht.

Das Wesen der Veränderungen in den Geweben besteht dabei in folgendem. Auf die Einlagerung des mit Dibenzanthrazen getränkten Eiweisses reagieren zuerst die Epidermiszellen, welche schon in den ersten Stunden nach der Operation locker werden, umfassen unmittelbar die aus den Wunden hervorragenden Eiweisstückchen, biegen sich ins Innere und drängen nach dem in den Hauttaschen liegenden Eiweiss. Die Epidermiszellen geraten dabei in Berührung mit den Erythrozyten, mit der geronnenen Lymphe und dem Blutplasma. Während dessen sind um das Eiweiss Erythrozyten zu bemerken, unter denen nur einzelne Leukozyten zu sehen sind. Aber schon in den ersten Tagen steigt die Menge der Polynukleaeren, welche nach dem Eiweiss zu drängen und an den Wundrändern mit dem in das Innere wuchernden Hautepithel in Berührung geraten. Schon während der ersten Tage nach der Operation bedeckt das Regenerationsepithel die Wundfläche, an den Wundrändern aber wuchert das Epithel stark nach Innen, drängt sich zungenförmig in das Eiweiss, lockert es auf und histolysiert es wahrscheinlich auch. Zu dieser Zeit verstärkt sich die Infiltration der Epithelwucherungen mit Anhäufungen von Polynuklearen mit Eiweisstückchen, Erythrozyten in verschiedenen Stadien des Zerfalls, mit Flocken von degenerierendem Pigment des Coriums. Die Ansammlung der Leukozytenmassen, besonders Polynuklearen, um das Eiweiss steigt, besonders an den, den Wundrändern gegenüberliegenden Enden der Hauttaschen. Das Eiweiss wird immer lockerer. Durch die erweiterten Blutgefässe geraten in das Eiweiss eine grosse Anzahl von Erythrozyten, wo sie in den Netzen des aufgelockerten Eiweisses liegen.

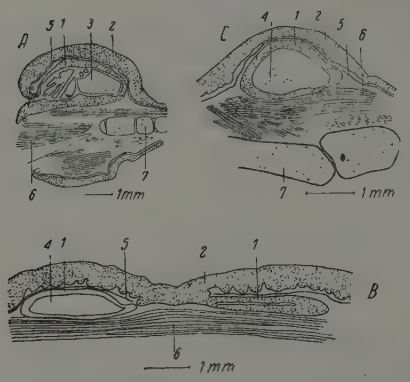

Abb. 1. *1*—Epithelröhre unter der Haut der Axolotlextremitäten, welche unter dem Einfluss des implantierten Dibenzanthrazen entstand. *A* und *B*—Längsschnitt, *C* –Querschnitt. *A*—13 Tage, *B*—26 Tage, *C*—244 Tage nach der Operation. *2*—Epidermis der Haut, *3*—Eiweiss mit Dibenzanthrazen getränkt, *4*—verhornte, abgestossene und degenerierende Epithelzellen, *5*—Cutis, *6*—Muskeln, *7*—Extremitätenskelett (schematisch).

Die Wucherung des Epithels nach dem Inneren geht äusserst stark weiter vor sich. Das Hautepithel umwächst in der Form eines Rohres das Eiweiss, welches von den Zellelementen des Blutes aufgelockert und umringt wurde. Dabei geht ein Zerfall eines Teiles der mit der umwachsenden Masse in Berührung kommenden Epithelzellen und Leydigschen Zellen vor sich. Solche Bilder sind schon zu Ende der zweiten Woche nach dem Versuchsbeginn zu beobachten (Abb. 1, *A*). An manchen Stellen bilden sich in der Epidermis selbst nach aussen drängende Abscesse. An den Wundrändern oder über den Einlagerungen findet eine Verletzung des Coriums und der Epidermis der Haut statt, es bilden sich Wunden, die durch die Eiweisstückchen, Po-

lynuklearen, Erythrozyten, einfache und Leydigsche Zellen der Epidermis, Pigmentzellen in verschiedenen Zerfallsstadien ausgespült werden. Die Epidermis über dem Implantat verdickt sich weiter, an manchen Stellen bildet sie im Inneren dichte zungenartige Gebilde oder Auswüchse, welche dem unter ihm liegenden feinzelligen Infiltrat und Eiweisstückchen zugewandt sind. Gleichzeitig mit dem allmählichen Abklingen der Entzündung werden die Epithelröhren immer klarer (Abb. 1, *B*, *C*). Ihre inneren Wände verdichten sich, ihre Zellen treten hervor und ein Teil von ihnen verhornt; sie werden allmählich abgestossen und degenerieren im Röhrenlumen.

Also sehen wir, dass die Implantation, mit 1 : 2 : 5 : 6-Dibenzanthrazen getränktem Eiweiss eine Entzündung hervorruft, die am Ende sich morphologisch in den sich unter der Haut der Axolotlextremitäten gebildeten Epithelröhren, mit dichten Wänden aus einfachem Epithel und Leydigschen Zellen bestehend, äussert. Das Eiweiss und die Zelleninfiltrate bleiben nicht erhalten. An der Stelle, wo die Epithelröhren in die Epidermis der Haut übergehen, bleibt eine Öffnung. Indem sich die Epithelröhren von den Wundrändern aus weiter unter der Haut entwickeln, ziehen sie wahrscheinlich die Hautoberfläche ins Innere, was die Entstehung der Narbe oder Spuren der früheren Wunde zur Folge hat. Ausser den langen Röhren sind an manchen Stellen auch kleine dichte Epithelwucherungen der Haut im Inneren vorhanden. Bösartige Gebilde entstehen nicht.

Es ist klar, dass man unter dem Einfluss des Dibenzanthrazen eine Entzündung erhält, welche zu atypischen Epithelwucherungen der Axolotlhaut führt. Ebenso ist auch klar, dass diese Epithelwucherungen das Dibenzanthrazen und die Entzündungsprodukte aus dem Organismus eliminieren. Zu solchen Typen der Epithelwucherungen gehören auch die Epithelwucherungen der Axolotlhaut, welche Nasonov bei der Implantation von Knorpel der Eidechse, Alkohol und Ätherextrakte des Axolotlknorpels und Kiemenstückchen erhielt (1).

Die Bildung der atypischen Epithelwucherungen bei verschiedenen Tieren unter dem Einfluss der verschiedensten Stoffe, dabei auch von kanzerogenen Kohlenwasserstoffen, spricht, wie das in der Literatur schon öfter betont wurde, gegen die chemische Spezifität ihrer Wirkung. Die Ergebnisse unserer Versuche zeigen weitaus klarer als die Versuche von Peredelsky (unveröffentlicht), dass bei der Wucherung des Epithels in das darunterliegende Gewebe in letzterem keine morphologischen Veränderungen vor sich gehen, was gegen die Anschauungen von Lasarenko, Garschin (2) und anderen spricht. Die Wucherung des Hautepithels in der Richtung auf das mit Dibenzanthrazen getränkte Eiweiss geht sofort nach der Operation vor sich, bevor irgendwelche morphologische Veränderungen im unterliegenden Gewebe stattfinden. Wahrscheinlich, kann hier von einem unmittelbarem chemotaxischen Reiz des Epithels von seiten des Dibenzanthrazens gesprochen werden. Nachdem eine unmittelbare Verbindung zwischen dem wuchernden Epithel und Zellinfiltrat hergestellt ist, infolgedessen der Wucherungsprozess der Epidermis unter der Haut weiter geht, besteht schon eine indirekte Wirkung des Dibenzanthrazens auf das Epithel.

Die Bildung morphologisch ähnlicher Gebilde in den Versuchen von Nasonov und in den meinigen mit Dibenzanthrazen—Epithelialröhren, welche aus der Epidermis unter die Axolotlhaut wuchern,—zeigt, dass das Dibenzanthrazen morphogenetisch als Invaginator wirkt, also eine Wirkung, wie dies die Gewebe und Stoffe zeigten, welche Nasonov angewandt hat, ausübt. Ungeachtet dessen, dass zwischen dem Grad der Äusserungen der Begleiterscheinungen ein grosser Unterschied besteht (schroffe Entzündung, welche in den Versuchen Nasonovs wahrscheinlich geringer zum Ausdruck kam, bedeutend grössere Epithelgebilde, welche ich in meinen Versuchen

mit Dibenzanthrazen erhielt), ist der Mechanismus der Invaginatorenwirkung in beiden Fällen gleich.

Es ist klar, dass zu den Invaginatoren Nasonovs, als Organisatoren, alle diese Stoffe gehören, welche eine atypische Epithelwucherung hervorrufen. Wahrscheinlich schaffen sie in dem Organismus und seinen Geweben solche biophysisch-chemische Bedingungen oder Einwirkungen, welche für solche einfache morphologische Prozesse, wie Einstülpung oder Wucherung des Epithels, notwendig sind. Die Geschwindigkeit und der Grad der Entzündung, nach der die Epithelhaut das implantierte Dibenzanthrazen schnell eliminiert, erklärt auch die Abwesenheit von bösartigen Gebilden bei Axolotln in unseren Versuchen. Dieser Umstand und der einfache Bau der Haut führt dazu, dass sich bei Axolotln unter dem Einfluss von Dibenzanthrazen einfache morphologische Gebilde bilden, während sich bei Säugetieren ausgesprochene pathologische Erscheinungen äussern, welche das morphologische Wesen der Epithelwucherung verwischen.

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Übersetzt von G. Streich.

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EXPERIMENTAL MORPHOLOGY

ON THE RÔLE PLAYED BY THE NEURAL CREST IN THE DEVELOPMENT OF DORSAL FIN IN *URODELA*

By I. B. TERENTIEV

(Communicated by I. I. Schmalhausen, Member of the Academy, 23. I. 1941)

The purpose of the given work was to elucidate the rôle played by the neural crest (mesectoderm) in the localisation of the dorsal fin in *Urodela*. The dorsal fin is formed out of the dorsal ectoderm, while its supporting mesenchyme arises from the neural crest ([1]). At the same time the latter induces the dorsal fin ([2]). Although both these components are present in head and body, the fin is absent in the head; it appears in the gill region and increasing gradually in size it attains its maximum in the middle of the trunk. It was necessary to make clear why the fin is absent in the head and present in the body, and whether it is the neural crest or the ectoderm (the reacting material or the inductor) which is responsible for this fact. Some indication that it was the inductor which really was responsible for the localisation seemed to be suggested by its behaviour in the course of differentiation. It is well known that the mesectoderm of the head almost entirely forms the cartilage of the visceral skeleton, whereas the body mesectoderm never forms any cartilage ([3,6]).

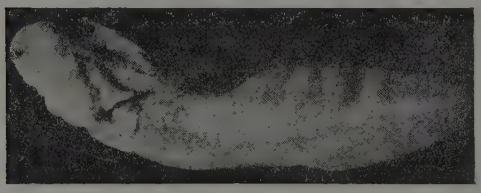
Four series of experiments on *Amblystoma mexicanum* and *Triton taeniatus* were carried out in order to clear the above problem. Embryos of *Hyla arborea* were also used. All the operations were carried out at the neurula stage (stages 15—17 after Harrison).

First Series. Transplantation of the ectoderm of the head region into the trunk region. Vital staining with Nil blue sulphate was applied to the graft. From the record drawings it may be seen that the transplanted head ectoderm developed in accord with its new position at the place of the removed dorsal ectoderm. In the majority of cases the graft took part in the formation of normal dorsal fins. Hence it is clear, that the head ectoderm may be induced and may participate in the formation of a normal dorsal fin.

Second Series. An area of the body medullary fold was grafted under the ectoderm of the head region, approximately into the region of the presumptive eye. In the positive cases (31 out of 44) spade-shaped and fin-shaped folds of ectoderm formed, located between the region of the ear vesicle and the eye, or somewhat more dorsally. Like normal fins, these fins were folds of ectoderm filled with supporting mesenchyme and scattered melanophores. Under the induced fins accumulations of cells reminding of ganglia could often be observed. In the negative cases no signs of the graft could mostly be detected. Consequently, the ectoderm of the head is

capable of forming a fin not only in the site of its normal localisation (the trunk), but in the head as well, in case the inductor is transplanted into it.

Third Series. This series served as control to the second series and differed from the latter only in that xenoplastic transplantations were practiced. In the first group *Hyla arborea* served as donor and *Tr. taeniatus* as host. In the second *Triton taeniatus* was donor and *Amblystoma mexicanum*— host. In both groups donor and host were chosen so that the cells of the donor be much smaller than those of the host. This procedure made it possible to trace the subsequent differentiation and behaviour of the tissue of donor (inductor) and host (reacting material). The results obtained were the same as in the preceding series. Histological sections showed besides that the ectodermal part of the fin is formed from the larger cells of the host, whereas the majority of the supporting mesenchyme consists of small cells of the donor. Thus, it is obvious that in this case we actually observe induction of local material rather than self-differentiation of the graft.



Result of a shift of medullary folds through 180°.

Fourth Series. Both medullary folds were shifted through 180° so that the trunk regions were transferred into the head and those of the head, into the trunk. These experiments were carried out in order to find out the inductive action of the head mesectoderm in the trunk, and vice versa. Ten axolotl embryos and eleven triton embryos were used. The results on both these test objects did not differ materially, though they proved not equally valuable. The results obtained on the larger axolotl embryos were more illustrative, since the operations performed on them were more successful. In the most successful cases (figure) one has the idea as if the anterior area of the fin of a formed larva was cut out and shifted in such a way, that its higher trunk area was transferred into the head and its lower occipital area, into the trunk. As a matter of fact, the inductor was shifted, while the reacting material remained in place. Unfortunately, the experimental embryos offered but scanty data as to the differentiation of the shifted folds, since they were fixed at a very early age (11—15-day-old). Great defects in the structure of the visceral skeleton could be noted, e. g. deficiencies of many elements of the gill-arches; similar deficiencies have been described by Raven in more detail (4). In the trunk under the area where the «shifted» fin vanishes, considerable accumulations of mesenchyme can be observed to surround the spinal cord.

From the data obtained one may conclude that aside from factors responsible for the localisation of the dorsal fin, the neural crest contains factors determining its shape as well. The following conclusions are to be drawn.

1) The ectoderm of both head and trunk is equally capable of forming the dorsal fin. It has only to come into contact with the necessary inductor.

2) The neural crest induces the fin both in head and trunk ectoderm. This is observed not only in case the head ectoderm is transplanted into the trunk area, but also when the trunk neural crest is grafted into the head region.

3) The neural crest of the head cannot induce a fin either in the head or the trunk ectoderm.

4) The localisation of the anterior margin of the fin on the level of the gills and the fact that it attains its maximum height in the middle of the body are due to the neural crest.

5) In the given case both the localisation and the shape of the organ are determined by the inductor. The action of the inductor is characterized by regionality which is manifested in the variation of its inductive effect within the area of head and trunk and in its differentiation as well.

The author's data do not stand apart from the rest of data obtained in modern development mechanics. Bytinski-Salz [4] showed that the neural crest of the trunk is incapable of inducing a fin in *Euricea bislineata* (larvae of *E. bislineata* have fins only on their tail), while the ectoderm of *E. bislineata* transplanted on to the back of a variety normally having a fin (*Amblystoma maculatum*) produces a fin.

The regionality in the action of the inductor has also been proved for the roof of the archenteron, the so-called primary organizer [5]. The regionality of the action of the latter consists in that its trunk area induces in most cases trunk organs, while its head area induces organs of the head [5]. Since it is known that the development of the neural crest is closely connected with the medullary plate, while the latter in its turn develops in close contact with the primary organizer, it can be assumed that the regionality of the neural crest depends in the long run on the regionality of the primary organizer. Our experiments have shown, however, that it is the regionality of the neural crest that plays a direct rôle in the development of the dorsal fin. The regionality of the neural crest is, besides, manifest in the fact that its inductive activity with respect to the dorsal fin is zero when evaluated at the head area, while it begins to become apparent about the level of the gills, regularly increasing in the caudal direction, until it reaches its maximum in the middle of the trunk.

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ZOOLOGIE

DIE VERÄNDERUNGEN DER ATMUNGSINTENSITÄT BEI *BURSARIA TRUNCATELLA* BEI EINWIRKUNG VON HUNGER UND CYANKALIUM

Von W. W. BARBARIN und L. M. SOLOWJEWA

(Vorgelegt von I. I. Schmalhausen, Mitglied der Akademie, den 10. I. 1941)

In speziellen Experimenten über die Wirkung von Sauerstoffentzug auf hungernde Infusorien (1) gelang es festzustellen, dass bei hungernden *Paramaecium* eine Sensibilitätssteigerung gegenüber Sauerstoffmangel entsteht. Später (2) wurden Beobachtungen angestellt über Sensibilitätssteigerung der gleichen Infusorien bei Hungerzustand gegenüber KCN-Lösungen. Da nach der Theorie von Warburg (3) O_2-Mangel und Cyankalium in letalen Konzentrationen eine Wirkung vom selben Typus auf den Atemmechanismus der Zelle hervorrufen, lässt sich vermuten, dass eine Verstärkerung der Atmungsintensität während der Hungerperiode vorliegt. Als Versuchsmaterial diente *Bursaria truncatella*, das wegen seiner beträchtlichen Grösse (Länge bis 1.5 mm) ein überaus günstiges Objekt für respiratorische Messungen darstellt. Es wurde eine Klon-Kultur verwendet, die nach der Methode von L. M. Solowjewa in abgekochtem und durchlüftetem Wasser gezüchtet wurde. Die Respiration der Infusorien wurde mit dem Warburgschen Spirometer gemessen. Die Kammer enthielt in sämtlichen Versuchen je 150 Infusorien, deren Atmung im Verlauf von 2 Stunden 30 Minuten gemessen wurde.

Die weiter unten angeführten Befunde zeigen, dass das Warburgsche Spirometer für respiratorische Messungen an *Bursaria* gut geeignet ist. Die erzielte Befunde, die wir in Tabelle 1 anführen, bestätigen vollauf die früher aufgestellte Vermutung, dass wir es bei hungernden Infusorien mit einer verstärkten Atemtätigkeit zu tun haben.

In allen oben angeführten Versuchsergebnissen lässt sich feststellen, dass am ersten Hungertag eine Senkung der Atemtätigkeit auftritt, die zu den späteren Fristen des Hungerzustandes in eine allmähliche Steigerung ihrer Intensität übergeht. Die absoluten Werte der Atmung hungernder Infusorien kann man noch höher annehemen, wenn man die ganz regelmässig eintretende Verminderung der lebenden Körpermasse berücksichtigt, d. h. während der letzten Hungerstadien verkleinern sich die Infusorien ums 2—3-fache gegenüber den normalen Kontrollinfusorien, und die Atmungsgrösse hängt doch zweifellos direkt von der Körpergrösse der Infusorien ab.

Eine Anzahl von Autoren sind bei der Untersuchung der Atmung von Protozoen zu der Schlussfolgerung gelangt (5,6,7), dass die Atmung der Infusorien einen Atmungstypus darstellt, der durch Cyanide nicht gehemmt

Tabelle 1

Respiratorische Veränderungen bei *Bursaria truncatella* im Hungerzustand

1. Versuch	Kontrolle 2.85*	23 Std. Hunger 1.50	40 Std. Hunger 3.63	
2. Versuch	Kontrolle 2.80	24 Std. Hunger 1.90	40 Std. Hunger 3.10	65 Std. Hunger 3.85
3. Versuch	Kontrolle 2.70	25 Std. Hunger 2.35	41 Std. Hunger 3.50	
4. Versuch	Kontrolle 3.00	25 Std. Hunger 2.30	38 Std. Hunger 4.60	45 td. Hunger 4.90
5. Versuch	Kontrolle 2.55	25 Std. Hunger 1.05	53 Std. Hunger 3.30	

* Skalaeinteilung des Spirometers in Zentimetern.

wird. Andere Autoren ([4],[8]) sind der Ansicht, dass Cyanide eine hemmende Wirkung auf den Atmungsprozess der Infusorien ausüben und folglich ein spezifisches Atmungsgift für dieselben darstellen. Barbarin ([1], [2]) fand bei seinen Untersuchungen an hungernden *Paramaecium caudatum*, dass die Wikrung von Sauerstoffmangel und von Cyanidlösungen während der Hungerperiode eine gleichartige ist. Denselben Parallelismus in der Wirkung dieser beiden Faktoren stellt Solowjewa (1940) bei ihren Untersuchungen an Konjugaten von *Bursaria truncatella* fest. Wir selbst bewerten zunächst die Tatsache der gleichartigen Wirkung von O_2-Mangel und von KCN-Lösungen nur als einen indirekten Beweis dafür, dass Cyanide für Infusorien ein Atmungsgift darstellen. Unserer Meinung nach kann nur direkte Messung der Respiration von Infusorien, die unter der Wirkng von KCN stehen, die Frage entscheiden, ob es sich hier um eine spezifische Wirkung der Cyanide auf den Atmungsvorgang handelt. Nachfolgend führen wir die Resultate der von uns angestellten Versuche an, in denen die Atmung von Infusorien gemessen wurde, die der Einwirkung von Cyankalium unterworfen waren.

Bursaria truncatella wurde in KCN-Lösung von Konzentration *N*/1000 gesetzt. Die toxische Wirkung dieser Cyanidkonzentration auf die Infusorien war so schwach, dass dieselben, nach Versuchsabschluss in der Cyankaliumlösung gelassen, noch 24 bis 48 Stunden lebensfähig blieben. Die Veränderungen in der Atmungsintensität, die bereits 30 Min. nach Versuchsbeginn auftraten, stehen also in keinem Zusammenhang mit dem Absterben der Infusorien infolge der Toxizität der Cyanidlösung (Tabelle 2).

Tabelle 2

Wirkung von KCN in Konz. *N*/1000 auf die Atmung von *B. truncatella* (150 Infusorien; Beobachtungsdauer 2 Std. 30 Min.)

1. Versuch		2. Versuch		3. Versuch		4. Versuch	
Kontrolle	Atmung in KCN	Kontrolle	Atmung in KCN	Kontrolle	Atmung in KCN	Kontrolle	Atmung in KCN
2.90	0.90	2.55	1.20	5.30	3.70	2.85	1.05

In allen oben angeführten Experimenten erfolgte bei den Infusorien eine starke Reduktion der Atemtätigkeit bereits 30 Min. nach Versuchsbeginn

bei Einwirkung von KCN in Konzentrationen, die bei weiterem Verbleiben der Infusorien in der Lösung noch mindestens 24 Stunden lang nicht tödlich wirken.

Die zweite Versuchsserie wurde mit zwei Typen von Kontrollen vorgenommen: 1) Infusorien in normalem Medium, 2) Infusorien in KCl-Lösungen *N*/150. Nach Versuchsabschluss bleiben die Infusorien in den KCl-Lösungen 20—30 Stunden lebensfähig. Die Lebensdauer von *B. truncatella* war demnach in den von uns verwendeten KCN- und KCl-Konzentrationen fast dieselbe (Tabelle 3).

Tabelle 3

Wirkung von KCN *N*/1000 und KCl *N*/150 auf die Atmung von *B. truncatella* (150 Infusorien; Beobachtungsdauer 2 Std. 30 Min.)

1. Versuch			2. Versuch				
Kontrolle	Atmung in KCl	Atmung in KCN	Kontrolle	Atmung in KCl	Atmung in KCl	Atmung in KCl	Atmung in KCN
4.90	4.65	1.00	5.70	5.35	5.30	5.70	1.30

Der Vergleich zwischen der Wirkung von KCN-Lösung *N*/1000 und KCl-Lösung *N*/150 gestattet die Schlussfolgerung, dass die Respirationssenkung bei *B. truncatella* in KCN-Lösung mit der allgemeinen Giftwirkung dieses Salzes in keinem Zusammenhang steht, sondern eine Folge der spezifischen hemmenden Wirkung des Cyanids auf den Atmungsprozess ist.

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